SOILS, SOCIETY & GLOBAL CHANGE

Proceedings of the International Forum
Celebrating the Centenary of Conservation and
Restoration of Soil and Vegetation in Iceland

31 August - 4 September 2007, Selfoss, Iceland

Edited by
Harriet Bigas
Gudmundur Ingi Gudbrandsson
Luca Montanarella
and
Andrés Arnalds

A Joint Publication

UNITED NATIONS UNIVERSITY
UNU-INWEH
International Network on Water, Environment and Health

Soil Conservation Service Iceland

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Soils, Society & Global Change

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Don't Forget the Soil!

Edited by Harriet Bigas, Gudmundur Ingi Gudbrandsson,
Luca Montanarella *and* Andres Arnalds

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The Soil Conservation Service of Iceland (SCS) is a governmental agency under the Ministry for the Environment. The SCS is charged with combating desertification, sand encroachment and other soil erosion, and promoting sustainable land use and reclamation and restoration of degraded land. The work is on different levels, from policy-making and research, to extension services and management of large- and small-scale reclamation projects.

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Contents

Preface xi

Acknowledgements xii

Forum Summary 1

Forum Addresses 7

Dr. Ólafur Ragnar Grímsson, *President of Iceland* 9
Mr. Einar K. Gudfinnsson, *Minister of Fisheries and Agriculture* 12
Dr. Rajendra K. Pachauri, *Chairman of the Intergovernmental Panel on Climate Change and Director-General of TERI* . 14
Food and Agriculture Organization of the United Nations, *Parviz Koohafkan* 17
United Nations Convention to Combat Desertification, *Goodspeed Kopolo* 19
United Nations Convention on Biological Diversity, *Jaime Webbe* 21
United Nations Environment Programme, *Gemma Shepherd* 22
European Commission, Directorate-General, Joint Research Centre, *Luca Montanarella* 24
The Iceland Forest Service, *Thröstur Eysteinsson* 25
The Farmers Association of Iceland, *Sigurgeir Thorgeirsson* 26
United Nations Development Programme, *Olav Kjørven* 27
United Nations Framework Convention on Climate Change, *Halldor Thorgeirsson* 30
United Nations University, *Zafar Adeel* 31
United States Department of Agriculture – Natural Resources Conservation Service, *Dana York* 33

Forum Plenary 37

Session 1: Setting the Stage: Soils, Society and Global Change – Global and Local Perspectives 39

Soils and the Living Earth, *Ólafur Arnalds* 40
Global Land Degradation: State, Risks and Prospects under Global Change, *Uriel N. Safriel* 46
The Global, Social and Ethical Context of Sustainable Land Management, *Maryam Niamir-Fuller* 53
Land Degradation/Desertification, Society and Global Climate Change in Latin America, *Elena María Abraham and Ricardo Villalba* 57
Agriculture in African Drylands – A Poverty Trap?, *Sem T. Shikongo* 65
Iceland's Century of Conservation and Restoration of Soils and Vegetation, *Andrés Arnalds and Sveinn Runólfsson* 70

Session 2: Healthy Soils – Supporting Food Security, Water Provision, Poverty Reduction and Biodiversity 75

Agriculture, Land and the Global Environment, *Parviz Koohafkan* 76
Poverty at the Nexus of the Global Water Crisis and Desertification, *Zafar Adeel* 84
The Role of Ecological Restoration and Sustainable Land Management for Biodiversity, *Ása L. Aradóttir* 88
Capacity Building for Developing Legal and Policy Frameworks for Soil Conservation and Protection, *Ian Hannam* 93
A Global Systems Approach for Healthy Soils, *Michael Stocking* 99
The Economics of Ecosystem Services, *Mélanie Requier-Desjardins* 106

Session 3: Mitigating Climate Change through Restoration of Degraded Land 111

Soil Carbon Sequestration through Desertification Control, *Rattan Lal* 112
Carbon Finance and the Millennium Development Goals: Potentials, Opportunities and Barriers, *Maryam Niamir-Fuller, Robert Kelly and Jeffrey Biggs* 123
Harnessing Carbon Finance for Land Restoration: Can it be Done and Will it Work?, *Richard Tipper* 132
Opportunities for Climate Change Mitigation in Agriculture: A Semi-Quantitative Assessment of Costs and Reductions Levels, *Louis V. Verchot* 135
Can Iceland Become a Carbon Neutral Country by Reducing Emissions and Restoring Degraded Land?, *Árni Bragason and Andrés Arnalds* 142

Session 4: Creating an Enabling Environment **147**

Our Covenant with Earth: The Contribution of Soil Ethics to Our Planetary Future, *J. Ronald Engel* 148
Engaging Stakeholders in Integrated Natural Resource Management: Approaches and Guidelines from Landcare, *Delia C. Catacutan and Joseph Tanui* 154
Incentives and Disincentives: A Systematic Approach, *Paul Martin* 160
Global Gender Issues and Sustainable Land Management, *Mirey Atallah* 165

Forum Reports **169**

Forum Rapporteur's Overview, *Roger Crofts* 170
Working Group 1: Soil Stewardship and Land Care 175
Working Group 2: Soil Management for Promoting Synergies in the Implementation of the Three United Nations Rio Conventions 177
Working Group 3: Carbon Sequestration and Land Restoration 179
Working Group 4: Knowledge Management 182
Working Group 5: Capacity-building Approaches in Legislative and Policy Development Techniques 187

Programme for Action **191**

Forum Programme **195**

List of Participants **201**

Appendix 1: List of Acronyms **209**

Preface

Soil is one of the world’s most precious resources and society depends on its continuing productivity for survival. The quality of the land for food production, water storage and filtering, and other ecosystem services are fundamental to world peace in the future. However, misuse and mismanagement of the soil, ecosystem degradation, soil erosion and desertification are global problems of major proportions. These are critical causal factors affecting climate change, resulting in the loss of biological diversity, reducing environmental security, destabilising societies, endangering food security and increasing poverty. All of these issues are linked and soil is a critical component.

The global community will not be able to achieve goals essential to sustaining our future without a major improvement in the conservation and restoration of the world’s soil resources. The world will need to double food production by 2050 in order to just keep up with the current rate of population growth, and more food will need to be produced before the end of this century than that combined over the last 10,000 years. This is an enormous challenge. While demand for the soil’s services are growing, the problems of unsustainable land use practices are intensifying in many parts of the world. A creeping environmental crisis is affecting a growing proportion of the world’s population.

Land degradation is directly linked to global climate change in several ways. Loss of vegetative cover and soils is one of the main factors in global warming through the release of organic carbon into the atmosphere and a reduction in the carbon sequestration capacity of the land. At the same time, climate change exacerbates land degradation, primarily through changes in precipitation and evapo-transpiration patterns.

Reductions in ecosystem functioning, coupled with erosion of soil and reduction in soil nutrients and moisture, are a large component in the reduction of biodiversity in many parts of the world. This can in turn reduce production, accelerate land degradation and constrain our capacity for responding constructively to change while trying to meet current and future human needs.

Increasing food needs have mainly been met by clearing and irrigating more land, converting natural forests to agricultural land, and applying more fertilisers – unsustainable land use options that have had negative consequences on the health of soils, land and biodiversity. These options, however, are now narrowing. This is partly a result of the realisation of the effects of global greenhouse gas emissions and the loss of biodiversity, and partly a result of soil degradation.

These negative trends cannot be allowed to continue if societal needs, based on a properly functioning natural system, are to be met. A new vision is needed that places soil at the heart of global social, economic and environmental solutions. This was the task of a group of approximately 130 scientists, policy-makers, land users and private sector representatives from around the world who met at the International Forum on Soils, Society & Global Change, held at Selfoss, Iceland, 31 August to 4 September 2007. The aim of the Forum was to explore the synergistic roles of soil conservation and vegetation restoration in meeting local, regional and global environmental and social challenges, and to propose recommendations and action plans for achieving these goals.

The Forum was hosted by the Soil Conservation Service of Iceland, in partnership with Icelandic and international agencies, organizations and universities. It marked the centenary of organized soil conservation and land restoration in Iceland. With its extensive problems of land degradation and desertification, and its numerous success stories in halting severe soil erosion and in restoring damaged land, Iceland provided an excellent venue to discuss and evaluate the role of soils in sustaining society and environment.

The Government of Iceland and the Icelandic community have a history of working together to develop successful ecosystem restoration schemes for vast areas of severely degraded land, and protecting existing ecosystems and unique landscapes. This is reflected in the direct translation of the Icelandic name of the Soil Conservation Service as the “Healing-the-Land Institute”.

This book comprises the addresses and keynote papers given at the Forum and reports on the outcomes from plenary and working group discussions. The Rapporteur’s overview outlines some of the main issues of the Forum, and finally the book proposes a Programme for Action agreed to by the Forum participants.

While the challenges ahead are enormous and often overwhelming, this Forum has shown the potential and capacity that lies within us for change. The recommendations and calls for action that have emerged from this Forum are a result of a small gathering of dedicated individuals who have worked collectively to make a change. Let us continue in this direction to meet the global challenges ahead and ensure a sustainable management of our precious soil resources, ensuring a sustainable future for all.

Dr. Andrés Arnalds
Chair of the Organizing Committee

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The Forum was made possible thanks to the generous financial support of the Ministry for Foreign Affairs of Iceland, Nordic Council, Reykjavik Energy, Nordic House and Soil Conservation Service of Iceland. Additional funds were provided by the European Commission – Joint Research Centre – Institute for the Environment and Sustainability for the publishing and dissemination of the Proceedings.

Invaluable encouragement and support were provided by His Excellency Dr. Ólafur Ragnar Grímsson, President of Iceland, Patron to this Forum, and Mr. Sveinn Runólfsson, Director of the Soil Conservation Service of Iceland. Furthermore, a number of individuals were present to lend their support to the Forum; these included: Ms. Vigdís Finnbogadóttir, Former President of Iceland; Mr. Einar K. Gudfinnsson, Minister of Fisheries and Agriculture; Dr. Rajendra K. Pachauri, Director-General of Tata Energy and Resources Institute (TERI) and Chairman of the Intergovernmental Panel on Climate Change (IPCC); Mr. Halldor Thorgeirsson, Deputy Executive Secretary of the United Nations Framework Convention on Climate Change (UNFCCC); Mr. Olav Kjørven, Assistant Administrator and Director, Bureau for Development Policy, United Nations Development Programme (UNDP); and, Ms. Dana York, Associate Chief of the United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS).

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The logistical operations of the Forum were facilitated by a number of dedicated individuals; these include Ms. Birta Bjargardottir (Forum Assistant), Mr. Gudjón Magnússon, Mr. Jón Ragnar Björnsson, Mr. Ódinn Burkni Helgason of SCS and Ms. Margrét Á. Jónsdóttir of AUI. Further thanks are given to the staff of Iceland Travel, particularly Ms. Camilla Tvingmark, and to the staff of Hotel Selfoss for their tireless efforts. Field trips were organized by Dr. Gudmundur Halldórsson and Mr. Gudjón Magnússon of the SCS and Mr. Kristinn H. Thorsteinsson, Mr. Einar Gunnlaugsson and Mr. Gunnar Hjartarson of Reykjavik Energy. The field trips were guided by Dr. Ólafur Arnalds and Dr. Ása L. Aradóttir of the AUI; Mr. Sveinn Runólfsson, Dr. Andrés Arnalds and Dr. Gudmundur Halldórsson of the SCS; and Mr. Einar Gunnlaugsson and Mr. Gunnar Hjartarson of Reykjavík Energy. Great assistance was provided by Ms. Julieta Muñoz, Mr. Páll Valdimar Jónsson Kolka, Ms. Karen Pálsdóttir, Ms. Hrafnhildur Bragadóttir, Dr. Hafdís Hanna Ægisdóttir and Ms. Ingibjörg Elsa Björnsdóttir with the logistics and note-taking during the Working Group sessions. The media team comprised Mr. Terry Collins of UNU-INWEH and Mr. Gunnar Kvaran of SCS. Excellent reporting of the Forum was provided by Ms. Ingrid Barnsley and Ms. Julie Taylor for the Earth Negotiations Bulletin on behalf of the International Institue for Sustainable Development – Reporting Services. Profuse thanks are given to the SCS staff at Gunnarsholt for their warm hospitality and a memorable visit, and to the Reykjavik Energy staff at the Hellisheidi Power Plant for an unforgettable experience. The coordination and organization of the Forum was facilitated by Dr. Andrés Arnalds and Mr. Gudmundur Ingi Gudbrandsson of SCS, and Ms. Harriet Bigas of UNU-INWEH.

Finally, the Forum's success would not have been possible without the support of the Forum's participants, whose contributions, enthusiasm and continued interest ensured a meaningful venue for collaboration and an opportunity for future progress, and a memorable event.

Forum Summary

Forum Summary[1]

1. Introduction

The International Forum on Soils, Society & Global Change, held in Selfoss, Iceland from 31 August - 4 September 2007, marked the celebration by Iceland of a century of organized soil conservation and land restoration. Initiated in 1907, it is one of the oldest such undertakings in the world. This event was hosted by the state Soil Conservation Service of Iceland (SCS) and organized in partnership with several Icelandic institutions and a group of international and UN agencies, universities and non-governmental organizations. The President of Iceland, Dr. Ólafur Ragnar Grímsson, was the Patron of the Forum.

The Forum highlighted the synergistic roles of soil conservation and vegetation restoration in meeting local, regional and global environmental and social challenges. The important role of soil as a common denominator for the successful implementation of the key Multilateral Environmental Agreements (MEAs) received particular attention. The Forum further aimed to facilitate knowledge transfer and cross-fertilization of ideas through dialogue between scientists, policy-makers, land users and the business community. As such, the Forum brought together key stakeholders and specialists from around the world, representing a broad spectrum of disciplines and interests.

2. Forum Background and Context

Land degradation – manifest in the form of soil erosion and desertification – is a global problem of major proportion, and is hampering efforts to achieve the Millennium Development Goals (MDGs) in all eco-regions of the world. The Millennium Ecosystem Assessment has ranked land degradation among the world's greatest environmental challenges, affecting climate and biological diversity, reducing environmental security, destabilizing societies, endangering food and water security, and increasing poverty.

Land degradation is directly linked to global climate change in many ways, including reducing the carbon sequestration capacity of land, particularly as a result of soil erosion and loss of vegetation, and by creating adverse local weather patterns due to impacts on albedo from loss of vegetation cover. Conversely, climate change exacerbates land degradation, primarily through changes in precipitation and evapo-transpiration patterns, intensified further by the occurrence of extreme meteorological events. Increases in floods, droughts and fires are a consequence of a changing climate and deteriorating vegetation, and accelerate land degradation processes. Loss of soil and vegetation, or changes in soil nutrients and moisture, can lead to a loss in biodiversity. This in turn can reduce production and accelerate land degradation, and constrain our capacity for responding to change. The interlinkages between these global environmental problems are profound.

The Forum focused on innovative ways to collectively tackle the interrelated facets of these problems, in particular by the application of sustainable land management approaches. It emphasized the synergistic role of sustainable soil management and of ecosystem restoration in achieving the MDGs. In this context, the Forum explored where improvements could be made in linkages between the UN Conventions on Climate Change (UNFCCC), Combating Desertification (UNCCD) and Biological Diversity (CBD), to increase the effectiveness of their implementation. To sustainably manage land resources and reverse the damage caused by land degradation is an immediate and critically important challenge for the world.

3. Why Iceland?

Vast areas of land in Iceland have undergone extensive vegetation degradation and soil erosion since the beginning of human settlement in the ninth century. As much as half of the vegetative cover may have disappeared and a national survey completed in 1997 revealed that serious soil erosion is rampant in about 40% of the country.

The Government of Iceland and the Icelandic people have a history of working together to develop successful ecosystem restoration schemes for vast areas of severely degraded land. This is reflected in the direct translation of the Icelandic name of the Soil Conservation Service as the "Healing-the-Land Institute".

With its extensive problems of land degradation and desertification, and experiences from a century of practical soil conservation, Iceland provided the perfect venue to host an International Forum encouraging open discussions and promotion of cross-fertilization of ideas to fashion a consensus on the importance of soils. The Forum built on the linkages implicit among the Forum's participants and promoted the value of increasing synergies between different disciplines to help achieve sustainable land management in the 21st century.

4. Objectives of the Forum

The main aim of the Forum was to highlight land care and soil conservation as a global concern and to elaborate on the synergistic role of sustainable soil management and vegetation restoration in achieving sustainable land management goals. Specifically, the Forum's main objectives were:

[1]This summary is in part based on the report published by the International Institute for Sustainable Development (IISD) Reporting Services. The complete report is available online at http://www.iisd.ca/ymb/sdfss/html/ymbvol144num1e.html.

1) To develop an ethic of land care, accepted by land users and decision-makers, that increases understanding of, awareness and respect for soils and land resources.
2) To encourage greater experience, knowledge and innovation through dialogue between scientists, policy-makers, land users and the business community.
3) To enhance understanding of global change processes, especially how soil conservation and land restoration can help counter land degradation, climate change and biodiversity loss, and restore the provision of ecosystem services.
4) To share experience and knowledge gained during a century of soil conservation and vegetation restoration in Iceland with the international community.

The Forum offered a venue for experts and policy-makers to discuss and assess various approaches to achieving sustainable land management and increased synergies using soil as a common denominator, linking the many global environmental and social challenges with which we are faced.

5. Forum Programme

The Forum was held over five days and engaged a broad range of key stakeholders from around the world, including experts, researchers, government officials, policy-makers, civil society participants and community representatives, who participated in presentations, discussions and working group sessions on the Forum themes. Field excursions demonstrated the century-long Icelandic experience and expertise on soil conservation and land restoration, providing examples for other nations facing similar challenges. Working Groups on specific themes related to the subjects of the Forum delivered recommendations and plans of action on the various topics discussed. A final Forum statement, drafted and endorsed by all Forum participants, was presented, proposing actions and recommendations to be implemented beyond the Forum. The recommendations highlighted opportunities for the international community to come together to encourage the protection of soils and to strengthen collaboration between all users on soil management and protection as a means to addressing many of the interlinked global environmental and development challenges, including *inter alia*, land degradation, food and water security, poverty and climate change. The Forum concluded with a Celebration Event honouring one hundred years of soil conservation in Iceland.

a) Forum Opening

The opening session was chaired by Sveinn Runólfsson, Director of the Soil Conservation Service of Iceland. Opening remarks were presented by Einar K. Gudfinnsson, Minister of Fisheries and Agriculture. Further remarks on behalf of partner agencies were presented by: Parviz Koohafkan, FAO; Goodspeed Kopolo, UNCCD; Jaime Webbe, UNCBD; Gemma Shepherd, UNEP; and Luca Montanarella, EC-JRC.

b) Session 1: Setting the Stage: Soils, Society and Global Change – Global and Local Perspectives

Chair: Roger Crofts, IUCN World Commission on Protected Areas & Commission on Ecosystem Management

This session was in two parts. The first looked at the current status of soils worldwide, and their trends and future projections within a social and global context. The role of soil as a key component of the biosphere was emphasized, as well as its role as a resource on which the livelihoods and well-being of many people depend. Land degradation needs to be further understood, particularly in terms of the difference between land degradation processes, land use options causing the degradation and whether they are natural or human-induced ones, and the underlying drivers of land use, in particular the social and economic ones. The appropriate ethics, incentives and policies must be included in the fight against land degradation, though challenges remain in scaling up the policies needed to support these. Furthermore, presentations and discussions considered the lack of clarity and misunderstanding surrounding the current definition of desertification and the lack of consensus on such a definition. The interlinkages between land degradation, climate change and biodiversity need to be emphasized, which can be done through increased synergies between the respective UN Conventions (UNCCD, UNFCCC, UNCBD).

The second part of this session concentrated on local case studies exploring the links between soil and global change. Examples from Argentina, Namibia and Iceland were presented and each shared their unique perspective on addressing land and soil degradation issues. The efforts being made to address land degradation issues are many, and include integrated assessments of desertification, participatory and bottom-up approaches involving local communities, and alternative livelihood approaches compatible with the sustainable use of land and soil.

c) Session 2: Healthy Soils – Supporting Food Security, Water Provision, Poverty Reduction and Biodiversity

Chair: Magnús Jóhannesson, Icelandic Ministry for the Environment

This session focused on the importance of healthy soils for the functioning and sustainability of ecosystems and for human well-being. The presentations emphasized the crucial role of soil in food and agricultural production, the impacts of land degradation on human well-being when coupled with the world's dwindling water resources, and the negative impacts on ecosystem functioning resulting from biodiversity loss. Furthermore, national legal and policy frameworks for the conservation and protection of soils and soil management needs to be improved, particularly in their implementation, and positive examples can be learned from several developing countries. The session highlighted the important role sustainable land management can play in addressing these challenges, which can be done through an integrated systems approach that will yield multiple benefits across many areas, or through a multi-functioning economic analysis of ecosystem services.

d) Session 3: Mitigating Climate Change through Restoration of Degraded Land

Chair: Brynhildur Davídsdóttir, University of Iceland

This session looked at the options, opportunities and challenges for mitigating climate change through the restoration of degraded land. Carbon sequestration and carbon finance options were presented as means to not only mitigate climate change and control land degradation and desertification, but as means to development, most significantly in the area of poverty reduction. The limitations in the way current carbon finance schemes operate were seen as a drawback, and presenters emphasized the need for market development and market transformation for improvement of the Clean Development Mechanism (CDM). Developing countries should also benefit from carbon finance schemes, and local and rural communities should be targeted as a key resource for developing successful interventions. Alternate options for mitigating climate change were also presented and included land use, land-use change, forestry and biofuels. Finally, a case study of Iceland was presented to assess its potential for becoming a carbon-neutral country using carbon sequestration options through the restoration of land quality.

e) Session 4: Creating an Enabling Environment

Chair: Sizwe Mkhize, National Department of Agriculture, South Africa

This session focused on creating an enabling environment for better management of soils with a focus on integrated approaches for sustainable land use and management. Presentations and discussions highlighted the need for the inclusion of soil ethics in the approach to soil management through a global earth covenant, the need for a better understanding of knowledge systems, and the need for inclusion of people at the core of sustainable natural resources management and a better understanding of their behaviour through an examination of incentives and disincentives. Integrated approaches were seen as favourable for addressing the complex multifaceted contexts underlying soil and land degradation. Furthermore, the involvement of local communities and gender mainstreaming policies need to be given more consideration for increased participation of these populations in sustainable land management processes at all levels and stages.

f) Parallel Working Group Sessions

The Forum included five Working Groups (WG) whose purpose was to further discuss and explore the topics presented during the plenary presentations with the aim of proposing recommendations and actions for implementation as part of the Forum outcomes.

WG1: Soil stewardship and land care. Chair: Andrew Campbell, Triple Helix Consulting. The group considered the role of land care approaches in sustainable land management and the development of guiding principles and ethics on soil stewardship and land care.

WG2: Soil management and the Multilateral Environmental Agreements. Co-Chairs: Luca Montanarella, EC-JRC and Youba Sokona, OSS. The group focused on means and recommendations to encourage sustainable soil management as part of a broader process of enhancing cooperation in the implementation of the Rio Conventions (UNCBD, UNFCCC, UNCCD).

WG3: Carbon sequestration, carbon markets and land restoration. Chair: Bal Ram Singh, Norwegian University of Life Sciences. The group considered recommendations for lifting barriers to help transform the carbon market in order to facilitate equitable and ethical carbon trading and in order to encourage the sequestration of an increased proportion of global carbon emissions through land restoration.

WG4: Knowledge management. Co-Chairs: David Niemeijer, Niemeijer Consul and Mary Seely, DRFN. The group's aim was to analyze and discuss how knowledge management can lead to a more thorough and systematic understanding of the linkages between soils, climate and society and to improved responses to related challenges.

WG5: Capacity-building for legislative and policy development in soil management. Chair: Robert Fowler, University of South Australia. The group aimed to address how to improve legal and policy frameworks for soil protection at the national and international levels, and considered possibilities for a new international instrument on soils, as well as linkages with and between relevant MEAs.

g) Session 5: Working Group Reports and Discussion

Chair: Anton Imeson, Amsterdam University

This session provided the Working Group Chairs with the opportunity to present the findings and outcomes that emerged during the discussions of their respective Working Groups to the Forum plenary. It was followed by an open discussion by all Forum participants, who endorsed the Working Group outcomes.

h) Session 6: Forum Conclusions, Recommendations and Discussion

Chair: Ingibjörg Svala Jónsdóttir, Land Restoration Training Programme, Iceland.

A Programme for Action for the Forum was presented to the plenary by the Forum Rapporteur, which included key findings from the Forum proceedings, as well as future opportunities and recommendations for action. Further amendments to the

Programme for Action were made and endorsed by the Forum plenary to reflect the key outcomes and recommendations made by the Working Groups.

i) Closing Session: Centennial Celebratory Event

Chairs: Kristín Ingólfsdóttir, University of Iceland; Ágúst Sigurdsson, Agricultural University of Iceland

The Closing Session was held to commemorate one hundred years of soil conservation and land restoration in Iceland. In his celebratory speech, the Forum's Patron, Ólafur Ragnar Grímsson, President of Iceland, recognized the progress made during the last century and called for new ways of translating scientific knowledge into problem-solving and policy-making for the future. Sveinn Runólfsson, Director of SCS, highlighted the main achievements of the SCS over the last century and outlined its goals for the future. Roger Crofts, IUCN World Commission on Protected Areas & Commission on Ecosystem Management, reflected on the challenges and opportunities presented by soil conservation in Iceland. Thröstur Eysteinsson, Iceland Forest Service, and Sigurgeir Thorgeirsson, Iceland Farmers Association, each emphasized the importance of soil and the role of forestry and agricultural in caring for the soil.

Closing remarks were presented by Olav Kjørven, UNDP; Halldór Thorgeirsson, UNFCCC; Zafar Adeel, UNU; and Jan Hartke, Clinton Foundation. They highlighted, *inter alia*, the importance of land to environmental and development issues; the need for action on climate change; the need for correct policy directions in developing countries and increased dialogue between the scientific and policy communities; and the involvement of the private sector in achieving change in the developing world. Dana York from the Natural Resources Conservation Service of the United States Department of Agriculture shared the agency's experience as a pioneering soil conservation service and encouraged a broader role for soil health within society. Finally, Rajendra Pachauri, Chairman of the IPCC and Director-General of TERI, highlighted the central role of soil to the health of the planet and to human well-being, and called for increased international attention on the linkages between soil and climate change. In his closing remarks, Andrés Arnalds, Chair of the Forum Organizing Committee and Assistant Director of SCS, pointed to key aspects of the Forum's Programme for Action, and encouraged immediate up-take of the recommendations and actions proposed by the Forum participants. He also noted the need for the continued promotion of key Forum messages put forth by all Forum participants in addressing future challenges.

Forum Addresses

Dr. Ólafur Ragnar Grímsson

President of Iceland

Sharing Knowledge and Experience: A Celebratory Speech Given on the Occasion of the Centenary of the Conservation of Soil and Vegetation in Iceland

It is with profound pleasure and excitement that I salute your conference and thank the distinguished experts and leaders for making the journey to Iceland. We meet at a time when the erosion of soil and vegetation poses the world with more complex and more difficult challenges than ever before.

Of course, my knowledge of soil science is somewhat limited and I am ready to admit that I have not entirely ploughed through the enormous Encyclopaedia of Soil Science Professor Rattan Lal presented to me when he first came to Iceland. But the Encyclopaedia is still on my table in the Presidential Library, not to be missed by anyone who attends the many meetings I host there, indicating to my visitors the importance for all of us, whatever our position or responsibilities, to understand the science of the soil.

Iceland is indeed a fitting location for our dialogue. Throughout the centuries the harsh natural conditions made life here a struggle for survival, often against impossible odds and all-powerful forces which eventually created the largest desert in Europe.

Medieval Icelandic literature describes how the country was covered with woods from the sea to the mountains, but the following centuries were a story of desertification due partly to overgrazing and exploitative chopping of the woods. The settlers cleared the trees for pastures, used them for firewood and charcoal. Within the first few centuries, about 80% of the original woodland had been cleared and the grasslands of the interior became the desert we can see today. The soil was carried from the highlands down to the lowlands and out to the sea.

It is indeed disturbing when we understand how this process of deterioration came about. The wood was wasted or burned, and due to grazing by sheep and rooting by pigs, seedlings could not possibly be regenerated. In his recent book *Collapse: How Societies Choose to Fail or Succeed*, Professor Jared Diamond discusses the Icelandic case of soil erosion as an illustration of a society that, as it were, chose to fail. The Icelandic experience throughout our early centuries was certainly a case of failure. For far too long the nation failed to appreciate the volatility and sensitivity of the vegetation, failed to understand the combination of factors that contributed to the withering of the soil.

It is tempting to ask: How on earth could this have happened? Were the settlers and their descendants of an exploitative frame of mind? What were they thinking? What is the lesson in the Icelandic journey?

Yes, it may have been a case of failure but our ancestors did not choose to fail. As Professor Diamond does in fact discuss in his influential book our case is a story of people finding themselves in new and unfamiliar circumstances, confronted with difficult problems of land management for which they were not prepared. Of course, there were volcanoes, geysers and glaciers, but Iceland nonetheless had looked similar to the regions in Norway and the British Isles that were familiar to the first generation of settlers who did not know, however, that the soil and vegetation of Iceland were much more fragile than the grasslands they were accustomed to farming. They found it natural to occupy the highlands and bring flocks of sheep there, just as had been done in Scotland. The result was that after the first centuries, Iceland became the country in Europe with the most serious ecological damage.

The Viking immigrants offer us an important lesson. They did not suddenly throw caution to the wind when they settled in Iceland, but they found themselves in an environment which appeared lush but was actually fragile. Their previous experience could not possibly have prepared them for the challenges ahead, somewhat akin to the situation facing the global community in our time.

The conservation of soil and vegetation ultimately became an important issue in my country, a development which began in the last stages of our campaign for independence. Towards the end of the 19^{th} century people with foresight and vision understood that special efforts were required. A crucial milestone was the establishment of special agencies for forestry and soil conservation in 1907, created only three years after the Danish Government had agreed to give Home Rule to Iceland, enabling the nation to leave the colonial past behind and establish authority over domestic affairs.

The agencies for forestry and soil conservation were symbols of a new era, reflecting the foresight and determination of the newly self-governing people who resolved to deal with modern challenges in a constructive and responsible manner. The Icelandic pioneers in soil conservation were empowered with energy and vision, courage and determination, and campaigned long and hard to protect the land and halt overgrazing to stop the exploitative utilization.

On this celebratory occasion, I pay homage to the distinguished scientists and officials who have led this effort in Iceland over the last one-hundred years and thank them for the leadership that has enabled the nation to witness success which also entails important lessons for others.

This Forum is therefore both a celebration of a remarkable journey and a manifestation of new ways of thinking: marking the search for methods to deal with global challenges we face here and now and in the decades to come.

It is indeed appropriate to preface our thoughts with reference to the Icelandic experience, for due to the rapidly changing natural environment people around the world are constantly finding themselves in circumstances for which their previous experience has failed to prepare them. Now more than ever, we must channel scientific knowledge and practical lessons into projects of paramount importance, but at the same time appreciate new ways of presenting complex tasks, mindful that our knowledge and understanding are inevitably always imperfect.

This mode of thinking must characterize how we approach the challenges which confront us, how we construct the necessary cooperation. The art of human existence is indeed the art of adjustment. We react to something which was not expected, not even imagined. As Francis Bacon – the great pioneer of modern science – put it some 400 years ago: “He that will not apply new remedies must expect new evils; for time is the greatest innovator.”

In recent years, we have gained increasing awareness of how our eco-world is in fact a single system, how developments in a particular area of the grand mechanism of our existence may hitherto have undreamt-of consequences in another. Perhaps the most dramatic contemporary manifestation of this interdependence is the relationship we have come to understand between climate change and the destruction of the soil, how it constitutes a vicious cycle.

As land loses its cover and vegetation retreats, carbon-capturing capabilities are reduced, accelerating climate change. Warmer years cause significant droughts, affecting water resources and an endless number of ecosystems, often furthering the spread of dangerous diseases. In many cases water reservoirs are disappearing. Enormous lakes – such as Lake Chad on the border between Nigeria, Niger, Cameroon and Chad – have all but evaporated, leaving the land to wither into dust.

The comprehensive nature of the global challenge is coming into ever starker relief, as illustrated by the words of Monyane Molelek, the Foreign Minister of Lesotho, who described how climate change is profoundly affecting the agriculture of his country. He said: "The farmers are suffering because nothing happens when it is supposed to. The traditional rainy seasons are no longer predictable. The numbers of droughts have doubled since the late 1970s and when the rains come, they come in torrents."

These environmental challenges consequently translate into human conflicts, soil erosion becoming the root cause of humanitarian crises, ethnic confrontation, vicious and tragic. The crisis in Darfur is but one example. In a score of countries, in Africa, Asia and other parts of the world, the deteriorating quality of the land and the enlargement of the deserts threaten to sow the seeds of enormous crises and conflicts in the years to come.

An ever-changing natural environment brings us enormously complex and difficult challenges, demonstrating clearly the imperative need for fresh approaches, new ways in which the international community addresses urgent policy decisions, translates scientific knowledge into improved and more effective ways of solving practical problems. Cooperation is called for more strongly than ever and the sharing of knowledge and experience across national borders is an imperative task.

In the same vein as Iceland is already sharing with others in different parts of the world how to explore and develop clean energy, we are now eager to bring to people in other countries the experience and practical wisdom which Icelandic scientists and public leaders have gathered in the field of soil preservation. If efforts to nurture vegetation and avoid excessive grazing could achieve success in the harsh northern climate, they could surely be effective, for example, in Africa and South Asia, because the Icelandic journey demonstrates that desertification is not only a problem for the tropics.

From the experience of Iceland and the recommendations made at this Forum, we can, together I hope, formulate an Action Programme that could bring renewed enthusiasm to the much-needed global cooperation. We must not wait because time is of the essence. Allow me therefore to suggest some elements of such an Action Programme:

1) The expansion of the training programme for experts from developing countries which Iceland has now established, the first trainees being present at this Forum. This programme can enable many to learn from our experience in the same way as more than 300 experts from all over the world have been trained in geothermal energy and fisheries programmes which Iceland has run as our contribution to the United Nations University.

2) Encourage the establishment of field laboratories conducting site-specific research on desertification control, providing further training opportunities for researchers and practitioners. One such field laboratory to serve as a model could be located here in Iceland.

3) Send scientists and people with practical experience as envoys to locations judged to be of particular relevance, for example to Malawi, Zambia, Ghana and Senegal in Africa, or in the states of Haryana, Rajasthan and Andhra Pradesh in India, or in the lower and middle Himalayas in Nepal. The envoys could bring to these locations new modes of thinking concerning the selection and adoption of land use, and new technologies to restore degraded soils and ecosystems, bringing the projects to the grass-roots level and fostering active participation of the farming communities, by people in villages which are home to more than a billion people the world over.

4) Initiate efforts to assess desertification controls and restorative technologies in a range of regions in Africa, Asia and Latin America, as well as efforts to enhance the carbon pool in soils and trees worldwide.

5) The creation of a comprehensive system of tradable carbon credits linking it to the monitoring of changes in land use and the ecosystem carbon pool.

6) Establish ways to use the income stream generated by carbon trading to provide incentives to restore degraded soils and ecosystems. For such a purpose, we could create what I call a "Desertification Control and Carbon Trading Centre" in order to facilitate scientific exchanges and promote the adoption of new technologies.

7) Improve existing programmes for graduate research and create networks of research cooperation in order to foster the growth of a global community of committed scientists.

8) Raise the awareness among people and nations of the causes and consequences of desertification and emphasize the benefits of soil preservation to carbon sequestration.

9) Encourage the community of scientists and experts all over the world to increasingly collaborate with governments and international authorities, and engage both the private sector and civil society to think in constructive and novel ways. If the four pillars of modern society – scientific communities, governments, business sectors and civic associations – could unite and combine their resources, we can build the foundations for enormous success.

In conclusion, let me emphasize that like the medieval settlers of Iceland, we find ourselves in a new era. Like them, we can neither foresee nor prepare for the unexpected, but must now do our best to improve our understanding and act constructively in new modes of cooperation.

This Forum and others like it can be instrumental in such a process of learning and cooperation and encourage new policies formulated on firm scientific foundations. There are in fact no limits to what can be achieved, but the enormity of our tasks obliges us to combine our resources in order to bring help to where the need in terms of human lives is enormous and urgent.

If we succeed in sharing our knowledge and experience across national borders and with all social sectors, we can indeed create a new beginning.

Mr. Einar K. Gudfinnsson

Minister of Fisheries and Agriculture, Iceland

Opening Address

Mr. Chairman, Distinguished Guests,

I welcome you to this important gathering here in Selfoss to deliberate on Soils, Society and Global Change. It is a pressing and timely subject. At the same time, we will use the occasion here in Iceland to reflect on our efforts in restoring our damaged ecosystems during the last century.

At the turn of the nineteenth century many things were happening simultaneously in Iceland. Icelanders were reassessing their ties to the Danish state and its monarch, home rule was established in 1904, independence followed in 1918 and the establishment of the republic in 1944.

A law on forestry, including the fight against soil erosion and moving sand, was passed in Althingi on 22 November, 1907. The law marked the onset of systematic public efforts in these fields, although some initiatives had been taken earlier.

Ungmennafélag Íslands, the Youth Society of Iceland, was founded that same year of 1907. Chapters within the Youth Society were formed in all districts of the country. The emphasis was upon cultural and physical education, voluntary work in land betterment through tree planting and revegetation efforts. There was a general awakening. Optimism and commitment to improvement swept the country.

The law on forestry and on combating erosion is therefore closely linked to the resurrection of the Icelandic nation led by Hannes Hafstein, the first Icelandic Minister under home rule. Hannes Hafstein was a visionary and a poet, and galvanised the nation with his vision of improved life. The cornerstone was judicious use of natural resources of land and sea.

His poem Aldamótaljóð, Ode to the New Century, is often cited, especially these two verses:

The time will come, Iceland, when you will arise
from the depths of the ages, your birthright the prize.
Your energy will burst forth where hidden it lies,
your rocks clad once more in growth‘s colourful guise.

The time will come when the land‘s wounds are healed,
the countryside thriving, the moors clad with fields,
sons harvesting bread that the fertile soil yields,
culture will bloom in the new forest‘s shield.

The task was overwhelming. Erosion was rampant following a very cold and difficult century. Only small remains were left of the natural birch forests. They are estimated to have covered a quarter of the land surface at the time of settlement in the ninth century. Overexploitation was still present through the harvest of firewood and increased grazing pressure. The nation prevailed while the forests died.

Icelanders have a long tradition of seeking knowledge in other countries and adapting ideas and processes to national circumstances. It was therefore natural that Hannes Hafstein recruited a Danish forester, Agnar Kofoed Hansen, to shape and lead the new Forestry and Land Reclamation Institute. Kofoed Hansen had wide experience in reforestation, including sand dune containment in the Baltic countries. The experience and successes gained through establishing the windbreaks that saved the western districts of Jutland in Denmark was an inspiration for the work facing the Icelanders.

Kofoed Hansen was keenly aware of the special nature of the Icelandic soils and wrote a remarkable treatise on the loessial characteristics of these soils and their propensity for erosion, and the significance this had for the possibilities of tree growth. He received an offer of an honorary doctorate from the University of Krakow in Poland for this treatise. This is one of the first serious scientific papers on the special nature of Icelandic soils that have received increased attention in later years.

The work of the Forestry Service evolved in two main directions, on the one hand traditional forestry including management and trials with new introduced species, and on the other hand, the tough struggle to halt the extensive soil erosion and sand movement. It was deemed that these tasks would best be handled by two separate organisations; and so it has been since 1914. However, the two sister organisations, the Forestry Service of Iceland and the Soil Conservation Service of Iceland, with common roots in the law dating from 1907, share many goals and aspirations and cooperate extensively on many issues.

The headquarters for the Soil Conservation Service was built in the eye of the storm, literally, at the historic farm Gunnarsholt which had been abandoned because of serious sandstorms that had ravaged the formerly fertile farmland. Black basalt sand filled the air and destroyed the vegetation.

Gap vas Ginnunga en gras hvergi. "There was a great dark void and no grass", to quote the ancient poem Völuspá or Prophecy.

This afternoon and evening, we will visit Gunnarsholt. Our Chairman and Director of the Soil Conservation Service, Sveinn Runólfsson, will be our host and you will witness the transformation of land that was almost completely barren to the productive farmland that it is today.

To restore the whole of Iceland to good farmland that would sustain a productive farming community and growing urban population was the aim set forth at the beginning of the last century. In large districts, this has been successful and the Icelandic people keenly follow the work and successes of this centennial effort.

Energy, dedication, and enthusiasm are but a few of the positive attributes that can be used in praise of the staff of the Soil Conservation Service. There has always been a new frontier mindset and courage to enter new paths to improve on the results in containing the destructive forces of sand movement and revegetate barren land.

Due praise must also be given to the sister organisations that have worked closely with the Soil Conservation Service in research and innovation relating to sustainable land use and land reclamation. The efforts of the Agricultural University of Iceland, and its predecessor the Agricultural Research Institute, have contributed in no small measure to the success of this work. The Agricultural Advisory Service and farmers also deserve recognition for their role in large land reclamation projects. Here the spirit from the Youth Movement is still vibrantly alive.

Lastly, homage is gratefully given to persons and institutes of learning in other countries. Virtually all our scientific staff seeks their education abroad, leading to an exchange of ideas and new approaches. This has significantly impacted the progress made here in Iceland.

It is especially gratifying to be able to reciprocate by introducing this Icelandic model to the international community at this important Forum. We believe that the development of this work in our special environment may hold some interesting features that may be fruitfully employed in many of the developing countries that face the threats of desertification in much the same way as Icelanders did at the start of the last century.

The Icelandic government has decided that development cooperation will play a more significant role in the foreign policy of Iceland in the coming years. Our most successful examples of such cooperation are those where we share our own experience and know-how with countries that are now in a position akin to that which we experienced ourselves almost within living memory of present-day Icelanders.

Through the initiative of the Ministry for Foreign Affairs, a project has been launched in education and training in cooperation with developing countries. We wish to share our experiences with others who find themselves in a similar position as Icelanders at the beginning of the twentieth century. This model in development cooperation has been successfully applied in the fields of fisheries and geothermal energy utilisation.

It is therefore with a particular pleasure for us today to welcome a small group of young professionals from five countries that are taking part in a training course in soil conservation. This is a first small step towards a fully-fledged training programme that may within a few years become part of the United Nations University and the family of capacity-building programmes.

I extend my welcome and gratitude to you all for attending and contributing to this Forum. I wish you success with your important work.

Dr. Rajendra K. Pachauri

Director-General, Tata Energy and Resources Institute (TERI) and Chairman, Intergovernmental Panel on Climate Change (IPCC)

Honorary Speech Addressed to the International Forum on Soils, Society & Global Change on the Occasion of the Centennial Celebratory Event

President Ólafur Ragnar Grímsson, Distinguished Forum Participants, Ladies and Gentlemen,

I would like to take this opportunity to, firstly, congratulate you on putting together such an interesting programme and second, to congratulate you on the one hundred years of soil conservation that has been achieved in this country. I am delighted to have been invited to share with you a few concepts that I hope will be of some interest, particularly given the manner in which we are facing the threat of climate change in this world.

It's really no coincidence that in most languages of the world you will find that the term "earth" is used to describe a fistful of earth just as it is used to refer to this planet Earth. And this, I think, is reflective of the fact that when we talk about soil, when we talk about earth, we are essentially talking about the health of this planet as a whole. As we've seen from history, from all that human society has been through, those societies which did not take care of the earth and which did not promote stewardship of the earth ran themselves into a state of ruin. Based on what we have heard at this Forum, I think stewardship of the soil is really one of the most landmark challenges that we are facing in society today. This challenge has become even more complex in today's world because now it's not merely a question of soil and its stewardship, though these are very important issues. It is because now there is a whole other range of factors that will influence and have an impact on the quality and health of the soil. And it's necessary for us to look at these drivers of change and how they will impact the quality of soil in the future. This most certainly includes how humans are influencing the atmosphere of this earth. Because of the changes that are taking place in the composition of the air we breathe, and the consequential changes that are occurring to the climate, these actions will obviously also have a major impact on the quality of the soil.

During the Forum, references were made to ecosystem services, and we can all agree that these are indeed a complex system of all forms of life: animal, plant and micro-organisms. If we affect one part of this balance, then clearly we will create an imbalance all around. It's also true that the poor in this world are critically dependent on ecosystem services. Looking at the example of my native country of India, where we have widespread poverty despite the impressive economic growth of recent years, one knows that, for instance, when looking at the lives and livelihoods of the poor, nearly an estimated one-third of the goods and services that the poorest of the poor depend on come directly from diverse ecosystems. Therefore, if the ecosystems are degraded, then so are the livelihoods and the lives of these people who are already considered among the poorest in the world.

During this important and timely Forum, it has been proposed that the IPCC be asked to carry out an assessment of climate change and soil and land degradation. As an individual of the IPCC, I am in favour of such an initiative as it would have major impacts for the future of this planet. As a scientific body, I think it would certainly be of great relevance to carry out such an assessment, but the decision will have to be made by the IPCC plenary, and it may be a challenge to gain such acceptance.

Why should we be worrying about climate change, the impacts on soil, and the interrelationship between the two? First, climate change is taking place at an unprecedented rate; and second, this relationship is a subject that has unfortunately not yet received the kind of attention it deserves. We find, for instance, that there really isn't enough site-specific or location-specific assessment of how climate change is likely to impact soil conditions. And there is an enormous wealth of research which necessarily has to be made use of. I would like to take this opportunity to highlight some of the critical changes that are taking place with the earth's climate, which would benefit from very detailed investigation in terms of the impacts on soil and soil quality.

First, I would like to emphasize the authenticity of the three IPCC Working Group Reports. These are based on solid, observational evidence, and not just theoretical studies or modelling activities. It is from these reports that we can begin to come up with an analysis that is profound and solid. For example, we know that 11 of the 12 warmest years in recorded history have taken place in the last 12 years. If we look at the average surface temperature of the earth for a period of approximately 150 years, we find that warming is now accelerated, and it is during the last 12 years that we have had the hottest period in recorded history. In the 2007 IPCC assessment, average temperature increase during the 20th century has been at 0.74 °C, as opposed to 0.6 °C which was reported in the previous assessment of 2001. Sea level rise has increased to approximately 17 cm during the last century, and one might be tempted to say that this has no implications on soil quality. However, in actual fact, it does. Given that a large part of the earth is bounded by the ocean, including large nations with long coastlines, sea level rise will have a profound impact on these nations, their soil, and ultimately their people. The intrusion of sea water further inland is taking place at a very rapid rate, and this clearly has implications for soil quality and the salinity of soils. This is something that we must project for the future and use our knowledge to asses the implications, because this will certainly alter human activities in a profound way.

As far as precipitation is concerned, this is also something of extreme value to soil quality. The IPCC observation and assessment for the future is that precipitation will increase in the temperate regions of the world, but is decreasing and will continue to decrease in the subtropics and tropics and the Mediterranean region, though this will not occur uniformly. Observations, along with supporting evidence, show that extreme precipitation events are also increasing. Though it's not possible to link any single event with human-induced climate change, aggregate data across the globe and over a period of time shows that these extreme precipitation events are becoming increasingly common, and certainly more severe. This obviously has major implications for the health of soils across the world.

We also know that floods and droughts are going to become more common and more severe, and this means that a lot of good quality soil is going to be washed away. It also means that during periods of drought, we can expect a decline in soil quality and changes in the micro-flora that exist in the soil. All of this will have many important rural, social and political implications. We can look at the current situation of Australia as an example: the fact that they have had a drought for the last 6 or 7 years has now entered into the political arena. On my recent visit to Australia, it was evident how much the national psyche has been influenced by the prolonged droughts that have taken place. It has now become an extremely important political issue.

My main concern lies with food security, as climate change intensifies other stresses. We know that there is growing water scarcity in several parts of the world, a growing decline in terms of soil quality and its productive capability, and climate change-induced impacts in terms of a decline in crops and their productivity. All of this is cause for great concern because several studies, as reported through the IPCC Working Group reports, clearly indicate that prices of food grains will go up with temperature increases induced by climate change. This means that the poorest countries in the world, and there are over 50 countries in the world that must import large or significant quantities of food in relation to their own consumption, may not be able to afford the import of enough food grains in the future. We are therefore on the verge of a process that will lead to a major human crisis and a series of serious global crises, threatening not only food security, but human security as well.

We are already in the midst of witnessing the impacts of lost soil quality in conflict situations around the world. For example, it can be argued that the breakdown of the social order and the system that existed in Afghanistan has strong roots in the decline of soil quality and agriculture in that country. In large areas, the quality of the soil has declined to a point where it can no longer be used to grow good crops. The conflict in Darfur revolves around many of the same issues. We therefore must concern ourselves with stemming the root cause of the problem in order to prevent further crises from occurring. A meeting of this broad nature is particularly important because, by definition, specialization means knowing more and more about less and less. At the same time, we are living in a world where everything is interconnected with everything else. When knowledgeable people from different disciplines come together, they bring with them their depth of knowledge of their particular fields. By linking this knowledge across in terms of its entirety, perhaps it will be possible to come up with policies and initiatives that may be able to save the future of humanity from a disaster, which will be inevitable if we don’t take enough action.

On the issue of climate change, Article 2 of the UN Framework Convention on Climate Change states the ultimate objective of the Convention is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the earth’s climate system. The term ”dangerous” includes actions that would threaten the ability of ecosystems to be able to recover on their own from the impacts of climate change. My main concern is that ”dangerous” is not something that can be applied uniformly across the globe. It is not a scientific understanding and it is not a scientific term; it is something that has to be based on value judgments. However, these value judgments will vary depending on conditions that exist in different parts of the world. We need to concern ourselves with the impacts of human-induced climate change on soil because if soils in different parts of the world reach a level where they become unproductive, as we are already seeing today, then dangerous levels of climate change will render the situation even more dangerous for some communities.

I would like to conclude with a few thoughts. If one looks at future projections of climate change, as the IPCC has done in its 4th Assessment Report, we have 2 sets of so-called “best estimates”; one at the lower range of future scenarios, which estimates global temperature to increase by approximately 1.8 °C by the end of this century; and the other, at the higher end of future scenarios, where global temperature increase is estimated at 4 °C by the end of this century. Either estimate, combined with the 0.74 °C increase that has already taken place in the last century, clearly provides an assessment of the direction in which we are heading. If we are to prevent any dangerous situation from occurring to the soil across different parts of the world, then we need to stem this increase in temperatures and the subsequent disruptions to the climate system that go along with it. It was very encouraging to hear during this Forum about the importance of carbon sequestration in our ecosystem. Ecosystems have lost a lot of carbon, and I think this is a major challenge for human society, as well as the scientific community. How do we begin recuperating some of this carbon that has been lost? There are also economic implications involved, and this may provide a basis for developing a new paradigm. I believe there’s also a need to start looking at the possibility of growing biomass fuels. Though we may not see oil run out completely, there will be security issues with the supply of oil and subsequently with the price of oil. Given this prospect, it’s time for us to use our ingenuity and see how we might be able to grow fuels on the ground. This possibility will only exist if there are soil conditions and enough water available to support it. If human society is to consider the range of possibilities that exist from the complex cycle between soils, photosynthesis, and the conversion of its products into usable fuels, then we have our challenge cut out for us. I see the potential from the participants gathered here at this Forum to carry these possibilities further.

A successful conference can be measured by two things. First, it can be measured though the range of participants that become involved, from practitioners to policy-makers to scientists, and the linkages that can be drawn between them. The wealth of knowledge that is gathered here at this Forum and that will emerge from it is of extreme value, because it is that which will move us forward. From my own limited experience in the field of climate change, I can see that the world is now waking up and paying attention to this issue, largely due to the amounts of new knowledge available. Without this knowledge, we would have carried on merrily believing our actions are not in any way affecting the climate of the earth. The second element of success is some degree of networking and follow-up action. To fashion an agenda, to come up with a set of issues that need further research and further intellectual endeavour will certainly succeed in getting the most out of this extremely useful and timely conference.

This is my second visit to Iceland, and I find it to be a fascinating country. It's a great privilege to know his Excellency the President Ólafur Ragnar Grímsson, who I think is a remarkable leader, not only of your country, but I would say of the global community at large. Once again, I would like to extend my congratulations to the Soil Conservation Service of Iceland for one hundred years of extremely successful service to society and to the country, and may I also thank you for giving me the opportunity to be a part of this event.

Thank you.

Food and Agriculture Organization of the United Nations

Address delivered at the Opening Session by Parviz Koohafkan, Director, Land and Water Division

While there has been formidable progress in increasing food production and economic growth, severe problems of food insecurity, poverty and environmental degradation persist, and are increasing in many areas. Over the past 40 years, per capita world food production has grown by 25%, and food prices in real terms have fallen by 40%. As a measure of this growth, average cereal yields were doubled in developing countries, whilst total cereal production has grown from 420 to nearly 1200 million tonnes per year. There is enough food to feed all the population of planet. However, recent FAO data records show that there are still over 850 million people hungry, a majority of which are women and children. Although there has been progress in increasing the average per capita consumption of food in some areas, there is a considerable problem of availability and access to this food due to poverty. The world clearly is not on track to achieve the World Food Summit (WFS) and Millennium Development Goals (MDG) targets of halving the number of hungry and poor by 2015 in many countries, particularly in Africa.

The battle to achieve WFS and MDG targets on poverty and hunger reduction and sustainable natural resources management will be lost or won in the rural areas. This is because, despite large scale urbanization, extreme poverty continues to be mainly a rural phenomenon. Of the world's 850 million hungry, 95% are concentrated in developing countries, mostly in rural areas. And of the world's 1.1 billion extremely poor people, 75% live in rural areas and depend largely on agriculture, forestry, fisheries and related activities for survival. For the rural poor, globalization and the increasing pressures of large industry, markets, and urban consumers have, on balance, been detrimental. In many places, these trends have forced small producers and farm families out of agriculture, or led them to excessive intensification and specialization, environmental degradation, and increased vulnerability to price fluctuations, the vagaries of weather, and pest and disease outbreaks. Tariffs, subsidies and other trade-distorting policies in developed countries have eroded the market share and revenues of exports by many developing countries. Competition between agriculture and other sectors for natural resources, particularly land and water, land degradation and desertification, loss of biological diversity and genetic resources, and more recent frequency of extreme events, have transformed the availability and use of natural resources, particularly in those fragile and critical ecosystems where poverty and hunger often prevail.

The increasing problems of desertification, salinization and water logging, the scarcity of water and increasing water pollution are clear indications that our ways of managing soils and water are not sustainable. Other examples include the contamination of soil and ground and surface water with nitrates and pesticides, eutrophication of inland and nearshore waters, problems associated with solid and liquid waste disposal and soil erosion and land degradation now common in all parts of the world.

The recent decade has seen the increasing frequency and severity of natural disasters – floods, droughts, landslides and wildfires – as a result of climate change and variability, but also as a result of increasing land pressures and misuse of lands and deteriorating soil quality and protective vegetation.

There has also been a marked decline in investment in agricultural and rural sector development. This has further limited the opportunities available to rural populations and contributed to rural stagnation, particularly in highlands, drylands, and fragile ecosystems in which the majority of the rural poor live. Clearly, a paradigm shift is urgently needed to address these problems. Reducing world poverty is not only a moral imperative and a social good, but it is also a global strategic priority for peace and stability and the survival of our planet.

Agriculture is a critical component of sustainable development and poverty alleviation, particularly in developing countries. Agriculture contributes to the economic, social and environmental priorities of sustainable development and has the capacity to bring solutions to many associated problems including employment generation, economic growth and environmental rehabilitation. It is both a problem and a solution to global socio-economic and environmental problems.

The challenge for future agriculture both in developing and developed countries is, therefore, to identify win-win options whereby sustainable intensification or changes in land use meet the demands of expanding population and economic development while reducing negative externalities of agricultural production and maintaining the goods and services provided by the environment.

Conservation agriculture (CA) is one of the promising options both in developed and developing countries. Conservation agriculture seeks the integrated use of a wide range of crop, soil, water, nutrient and pest management, building on farmer's local knowledge and improved technologies through participatory diagnosis and actions. Such regenerative and conservation-effective agriculture can be highly productive, provided farmers participate fully in all stages of technology development and extension. The Landcare movement, to which Iceland and many other countries have joined, is another successful solution for many biophysical and socio-economical angles of the poverty-environmental nexus. Individual farmers and farming communities come together to take care of their land and environment. Farmers are not just part of the problem – they are also part of the solution.

Balanced land access policies and programmes are needed to promote agricultural development and to protect more vulnerable groups against deepening poverty – particularly in a world where competition for access to resources and efficiency-enhancing land use change are the main drivers of the development process.

Farmers often lack incentives to consider the impacts of their decisions on environmental services. Improved information on opportunities and prices, fair trade and pro-poor policies and regulations can influence farmers' decisions in ways that enhance the environment. Payments for environmental services can increase the incomes of farmers who produce public goods and environmental services. Other poor households may also benefit, for example, from increased productivity of the soils they cultivate or improved quality of the water they drink.

Maximizing benefits and minimizing trade-offs in agriculture and natural resources management will require careful science and innovative institutions. Getting the science right is a critical first step. This requires an understanding of complex ecosystems functions and interactions and the relationships between farmers' actions and their environmental consequences. Understanding the socio-economic motives of small holders and constraints facing family farmers, suppliers and beneficiaries of environmental goods and services, would need a holistic approach where both socio-economic and cultural aspects are considered. Equally important are the institutional innovations needed to link suppliers and beneficiaries.

In conclusion, while the challenges of poverty reduction and sustainable development are formidable, the greater human capacity and ingenuity that brought about industrial and technological revolution would need a social and bio-cultural mindset to allow us to overcome these challenges. With the right policies, investments and political will to reach into poor communities, we can meet the formidable challenges of our century.

United Nations Convention to Combat Desertification

Address delivered at the Opening Session by Goodspeed Kopolo, Senior Programme Officer, UNCCD Secretariat

Recent discoveries have revealed an ancient soil management technique from the Amazon basin, practiced for thousands of years by the original inhabitants of the region before the advent of European explorers. Civilizations there had buried charcoal in tropical soils to make them productive. Their origin first erroneously attributed to volcanic eruptions, these patches of soil horizons known as *terra preta*, or "black earth," still remain bountiful five hundred years later. The charcoal acts like a coral reef for soil organisms and fungi, creating a rich micro-ecosystem where organic carbon is bound to minerals to form rich soil.

It has now been amply proven, on sound scientific ground, that simply burying charcoal (also known as "agri-char" or "bio char") in soil is beneficial. The advantages of bio char in agricultural soils are numerous:

1) It increases the water holding capacity of the soil.
2) It results in the formation of stable humus, which then provides a high and sustainable nutrient holding capacity, thereby increasing crop yield as well as encouraging permanent cropping. This in turn helps decrease the pressure on forests that are being extensively cleared for agricultural use.
3) Charcoal accelerates pollutant degradation, thereby neutralizing farm chemical run-off before it enters the hydrosphere, and causes persistent organic pollutants (POPs).
4) It reduces erosion by increasing aggregate stability of the soil.
5) It mitigates climate change, as charcoal formation during biomass burning is considered the only way that biomass carbon is transferred to long-term pools over geological time scales. Indeed, and more than five hundred years later, biomass carbon is still sequestered in these ancient man-made *terra preta* soils.

Accordingly, such a technology carries a tremendous potential and could represent a suitable alternative for 21st century agriculture, which is expected to produce food for billions of people.

This certainly represents one innovative way to collectively tackle the interrelated facets of the problems that confound mankind today, through the application of sustainable land management approaches.

However, whatever work has been done is too compartmentalized and ends up being stacked up in the ivory towers of research institutions. This highlights the fact that the world still sorely lacks a global soil and land protection strategy, despite the fact that soil scientists have long recognized that soil, and more broadly, land, is a valuable, finite resource, and that its sustainable future needs to be assured.

Therefore, unlike air and water, where there have long been monitoring networks in place, there is little information on the state of soil quality.

Nonetheless, statistics have been touted by the International Union of Soil Scientists: Over the last 300 years the average soil loss was 200 million tonnes per year; and in the past 50 years this average has reached 760 million tonnes per year. 6 million hectares in annual loss to soil degradation is irreversible. An estimated 2 billion ha require rehabilitation. The cost of rehabilitation over a 20-year period has been calculated to be about US$ 213 billion. If not rehabilitated however, the income foregone (over a 20-year period) could equal a staggering US$ 564 billion. The cost of replacing nutrients lost from arable land in countries of sub-Saharan Africa is estimated to range from <1% to as high as 25% of the national Agricultural Gross Domestic Product for selected countries. It is clear that the poor are most severely affected.

There is therefore a dire need for concerted efforts geared towards determining an optimum balance between short-term economic returns and longer-term investments in improved soil quality for more sustainable production. One in which the central role of soil for achieving the mandates of the Multilateral Environmental Agreements (MEAs) would also be the cardinal point.

Notwithstanding the various national and regional initiatives already underway, this would require a different approach for addressing the sustainable use of soil. In this regard, the UNCCD is best placed to host international and interdisciplinary concerted efforts to place soil at the heart of sustainable development for the following reasons:

- The UNCCD provides an intergovernmental and legal process that facilitates work at the international, regional and national levels with concrete obligations and in the context of an established framework and National Action Plan development at the country level.

- The UNCCD, as an integrated environment and sustainable development Convention, holds considerable potential to address the multi-level causes and consequences of soil and land degradation. This potential would be crucial for the success of any concerted international effort on soil.

- An achievable way forward would be to strengthen the role of science within the UNCCD process; a move that scientists have long been championing.

In this regard, the UNCCD already has extensive global backing, due to the relationship between desertification, land degradation, drought and soil. Also, firm foundations have been laid for developing regional and inter-regional cooperation and intergovernmental agreements for sustainable land management over the past decade of UNCCD operation. A soil initiative under the UNCCD framework could therefore benefit from the groundwork already undertaken.

Furthermore, meaningful strategic reflection is taking place within the UNCCD. Two Intergovernmental Working Groups that will report to the Conference of the Parties are discussing the direction of the Convention for the next ten years. This provides an important window of opportunity in which to explore the possibilities of developing a global consensus to guide the protection of soil under the UNCCD.

In addition, within this ten-year strategy, the Committee on Science and Technology (CST) is being drastically revamped, effectively answering the call to strengthen the role of science within the UNCCD process.

It is also important to note that we are moving towards Commission on Sustainable Development (CSD) 2008-2009, which has chosen soil, land and water as ground zero to ensure the sustainability of environmental conservation. This has been taken into account in the new UNCCD framework that is currently being forged, thereby providing more reason for soil advocates to act now, and hit the iron while it is hot, as it were, in order to achieve a soil initiative under the auspices of the UNCCD.

A unique opportunity is at hand for this alternative. The UNCCD COP8 is currently underway in Madrid. This Forum can make a decisive contribution on the way forward if the decisions of the Forum in this respect can be relayed to the CST of the UNCCD for inclusion in their recommendations to the COP. This Forum would then have given the much-needed impetus to the establishment of a truly holistic way of addressing the issue that takes the lessons learned from of our forerunners in the Amazon, to place soil at the core of sustainable development, and that puts to use at least some of the 100-year experience in “healing the land”, gained right here at our host institution, in the quest for the achievement of the Millennium Development Goals.

Thank you.

United Nations Convention on Biological Diversity

Address delivered at the Opening Session by Jaime Webbe, Programme Officer, Dry and Sub-Humid Lands

The Millennium Ecosystem Assessment has made it clear: over the past 50 years, we have changed ecosystems at a rate never before seen in human history. These changes are disrupting nutrient and water cycling, reducing outputs of food and fodder and posing serious threats to biodiversity. At the same time that ecosystem degradation and biodiversity loss is accelerating, the demand for natural resources is rising, and climate change is placing increasing stress on almost all natural systems.

The links between the degradation of ecosystems and the loss of biodiversity is perhaps most severe when the very basis of production is lost – namely, soil. The detrimental effects of land degradation, soil erosion and desertification on biodiversity and biodiversity-based livelihoods can be seen throughout the world. In Mexico, more than 45% of soils are affected by degradation, while in Zimbabwe, estimates of annual economic losses as a result of soil degradation reach 9% of agricultural Gross Domestic Product.

On the other hand, the conservation and sustainable use of biodiversity has multiple benefits for soil and society. Healthy soil is the basis for many livelihoods, provides a buffer against the negative impacts of global change on water resources, production and nutrient cycling, and represents a significant terrestrial carbon store.

The objectives of the CBD and its legal, policy and practical procedures play an important role in the implementation of activities in support of the conservation of soil biodiversity and the restoration of damaged soils, vegetation and ecosystems. The application of the ecosystem approach, for example, adopts a broad, inclusive approach to the management of all components of ecosystems, including people and biodiversity.

In addition to the ecosystem approach, the programme of work on agricultural biodiversity is scheduled for an in-depth review of implementation at the ninth meeting of the Conference of the Parties. At this time, the links between soil, biodiversity and production will be discussed within the framework of activity 2.1 on the role of soil and other below-ground biodiversity in supporting agricultural production systems, especially in nutrient cycling.

Furthermore, in recognition of the close links between biodiversity and desertification, the Convention has adopted a Joint Work Programme with the United Nations Convention to Combat Desertification towards the conservation and sustainable use of the biodiversity of dry and sub-humid lands. In recognition of the importance of soil to the achievement of the objectives of this programme of work, the sixth meeting of the Conference of the Parties called, through the Global Taxonomy Initiative, for increasing knowledge of the organisms that maintain the soil crust.

The eighth meeting of the Conference of the Parties to the Convention, followed by the twelfth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice called attention to the increasing challenges facing biodiversity at all levels as a result of global change in general and climate change in particular.

As global changes are manifested, it is more important than ever that we turn our attention to that biodiversity which forms the basis of production. Because of difficulties in assessing and monitoring soil biodiversity, the information available on the status and trends of this resource is sparse. Addressing this gap will better enable us to implement climate change response activities in a manner which considers soil biodiversity and all the services it provides.

United Nations Environment Programme

Address delivered at the Opening Session by Gemma Shepherd, Programme Officer, Division of Early Warning and Assessment

Your Excellency Ms. Vigdís Finnbogadóttir, Former President of Iceland;

Your Excellency Mr. Einar K. Gudfinnsson, Minister of Fisheries and Agriculture of Iceland;

Excellencies, Distinguished delegates, Representatives of UN and international agencies, Ladies and Gentlemen, dear Friends and Colleagues;

On behalf of the Executive Director of the United Nations Environment Programme (UNEP), Mr. Achim Steiner, I warmly welcome you to this Forum on Soils, Society & Global Change.

Over the last several decades, increasing human population, economic development and emergence of global markets have driven unprecedented land use and global change, resulting in immense pressure on soil resources. These pressures are projected to intensify further over the next several decades.

Will we cope?

The most dynamic changes have been in forest cover and composition, expansion and intensification of cropland, and the growth of urban areas. However it is not land use change that drives soil degradation as much as unsustainable land use: what matters most is how land is managed. Current land resources can support human needs only if sufficient investment is made in sustainable soil and environmental management.

In industrialized countries the primary concern is due to excess of nutrients and pollutants causing eutrophication, acidification, and soil contamination. Perhaps surprisingly, soil erosion continues to be a problem in Europe and North America, and may increase if rainfall intensity increases with climate change. These problems are being effectively tackled where a combination exists of knowledge, forceful social and economic policy, solid institutions maintaining supporting services, involvement of all parties, and tangible benefits to the land users.

In tropical developing countries, however, it is the lack of sufficient nutrient and management inputs for sustainable land management that is the main concern, leading to soil nutrient depletion, soil physical deterioration and erosion, and soil salinity. In these areas, soil degradation is threatening sustainability of food production and damaging the wider environment through effects on water quality and availability, further increasing vulnerability of already impoverished peoples. Effects spill over into adjacent ecosystems; for example, soil erosion in Kenya over a number of decades has damaged the coral reefs along the coast.

In these situations, major investment in soils is needed to prevent environmental damage. For example, in Africa only 11% of the continent, spread among many countries, has high quality soil that can be effectively managed to sustain more than double its current population. Most of the remaining useable land is of medium and low potential, with one or more major constraints for agriculture. These lands are at high risk of degradation under low input systems. Substantial investment in capacity-building and inputs for sustainable land management will be required to bring about improvements.

Excellencies, Ladies and Gentlemen,

Land degradation is also having global impacts through disruption of the biological cycles on which life depends. The runaway carbon cycle and its impacts on global warming are of utmost concern. Soil is both affected by and contributing to global warming. Soil contains more than twice the amount of carbon currently in CO_2 in the atmosphere, constituting one of the largest sources of carbon in the world. How we manage the global carbon store is critical for our survival.

Good soil management can bring about dual benefits of climate change mitigation and improved adaptation. Improved soil management could mitigate 5-15% of the global fossil fuel carbon emissions. This is significant and at the same time will improve soil quality, food security and the environment, which collectively improve adaptive capacity for climate and global change.

However, perhaps the greatest gains may come from measures to prevent further soil and land degradation. Mismanagement of forest soils, peatland and tundra soils could release massive amounts of carbon and methane into the atmosphere and greatly exacerbate global warming. For example, one-third of all terrestrial organic carbon is peat. In a ranking of countries based on their total CO_2 emissions, Indonesia comes 21^{st} if peatland emissions are excluded. However, if peatland emissions are included, Indonesia is already the third-largest CO_2 producer in the world. Strategies such as avoided peatland degradation and deforestation may cost less than one-hundredth of alternative emission reduction strategies and can provide additional adaptation and poverty alleviation benefits.

Land degradation over large areas of drylands, or desertification, is another serious global threat to human well-being and environment. Desertification currently affects between 100-200 million people and threatens the lives and livelihoods of a much larger number – more than one-quarter of the world's population depends on drylands in developing countries.

Desertification and poverty are mutually reinforcing, threatening livelihoods, for example through loss of food and water security, and increasing vulnerability to climatic variability. Desertification impacts are far reaching, affecting urban dwellers and people far from drylands, for example by affecting water quantity and quality for downstream users, through dust effects on human health, and through feedbacks on regional and global climate change. Desertification is already leading to social disruption: over the next ten years, 50 million people are estimated to be at risk of displacement as a result of desertification. People displaced by desertification are putting a new strain on natural resources in adjacent lands and threatening international stability.

UNEP has been fully engaged in soil management for over 30 years, through its partnerships with other UN agencies, governments, and a wide array of stakeholders. UNEP was primarily responsible for preparing the United Nations Conference on Desertification, which was held in Nairobi in 1977, and subsequently played a major role in the negotiating process leading to the United Nations Convention to Combat Desertification. UNEP has, and continues to support the implementation of the Convention through global environmental assessments, the development and implementation of projects, and policy support to regional, sub-regional and national action plans for combating desertification.

In the early 1980s, UNEP contributed to the development of the World Soils Policy, leading to the World Soil Charter, which established a set of principles for the optimum use of the world's land resources, for the improvement of their productivity, and for their conservation for future generations. In the early 1990s, UNEP, in cooperation with international partners, carried out global and regional assessments in order to gain fast and reliable data on the global status of human-induced soil degradation, culminating in the publication of the World Atlas of Desertification. UNEP has continued to develop its assessment framework to respond to the complexity of sustainable land management issues, through, for example, its Global Environmental Outlook assessments and the Millennium Ecosystem Assessment. We continue to develop initiatives to build integrated approaches to sustainable land management; for example, UNEP and the United Nations Development Programme are piloting climate change adaptation in eight developing countries under the One UN strategy.

Excellencies, Ladies and Gentlemen,

The threat to sustainable development posed by soil degradation has been recognized for decades, including by Our Common Future in 1987, the 1992 Earth Summit, and the 2002 World Summit on Sustainable Development. But the fundamental principles of sustainable land management are yet to be translated into globally effective policies and tools. Perhaps most alarming of all is the lack of systematic collection, analysis, and interpretation of scientifically sound data on land health that is directly linked to planning, implementation, and evaluation of policy and programmes for prevention and control of land degradation. Effective responses are still also held back by limited access to information, inadequate institutional capacity faced with complex land use issues, and the absence of broad participation or ownership of the responses.

Therefore, we welcome this Forum, which seeks to raise the importance of sustainable soil management in the global change agenda and promote dialogue between scientists, policy-makers, land users and business interests. We assure you of UNEP's utmost support for this process, and very much look forward to the outcomes of the Forum.

European Commission, Directorate-General, Joint Research Centre

Address delivered at the Opening Session by Luca Montanarella, EC-JRC

Excellencies, ladies and gentlemen,

Let me first of all thank the organizers of the meeting, and particularly Sveinn and Andrés, for having invited the European Commission to attend this challenging Forum. Let me add that I also personally enjoy attending today this Opening Session of the International Forum on Soils, Society & Global Change. I had the pleasure to attend exactly two years ago in this very same room a very successful international workshop on “Strategies, Science and Law for the Conservation of the World Soil Resources” and I’m sure that the meeting of today will be a similar success and will leave a long-lasting sign in the process of achieving soil protection in the world.

We are also here today to celebrate one-hundred years of soil conservation and land restoration in Iceland. This is a particularly important moment for soil protection both globally and in Europe, and therefore this centenary of the Icelandic experience is a good opportunity for taking stock of the lessons learned and the future challenges ahead. Iceland can be seen as a forerunner for what we need to do in other parts of the world. The history of its land teaches us that soil degradation caused by human activities can have very long-lasting impacts and may require centuries for recovery. Indeed, this is the reason for us to consider soil as a non-renewable natural resource, since it takes many generations to re-build the full richness of a well developed soil profile.

But let me go back to the main topic of this Forum: Soils, Society & Global Change. Bringing together experts on these three topics is already an achievement, and Iceland has already proven to be the right place for such interdisciplinary seminars. Soil science alone can achieve only little if not integrated in a wider context of society and global change. There is here the urgent need of opening the soil science community to the outside world of non-soil experts. Only in this way will we be able to substantially improve the effectiveness of soil protection strategies and really make progress towards sustainable soil use at a global scale.

Global change is the major environmental concern in today’s societies. Evidence of the impact of global warming is now visible also top the layman, and is becoming a global political priority. Also in that respect can Iceland be seen as a forerunner, by addressing comprehensive mitigation strategies that also include land restoration as a major component for achieving enhanced carbon storage in the topsoil.

As you know, we are in the process in Europe of defining our common European Union (EU) Strategy for Soil Protection that is very much taking into account the role of soils within the context of global change. Hopefully we will achieve our goal of establishing a European legal framework for soil protection that will allow the European Union to be at the forefront of the countries aiming towards mitigation of climate change.

We will certainly have very interesting and challenging exchanges of opinions and views on these issues that will certainly allow us to come up with some conclusions and recommendations to policy-makers on the way forward for achieving synergies among soils, society and global change for sustainable development and improved human livelihoods. A number of important political appointments are in front of us before the end of the year and this Forum could certainly contribute to stimulating a constructive political debate in these upcoming meetings. I’m thinking particularly of the upcoming Conference of Parties (COP) of the United Nations Convention to Combat Desertification (UNCCD) in Madrid that will take place immediately after this meeting, but also of the next COP of the United Nations Framework Convention on Climate Change (UNFCCC) in Bali that will offer another occasion for delivering ideas and options for policy-makers to debate on.

Let me conclude by wishing you all a successful and productive meeting.

The Iceland Forest Service

Address delivered at the Closing Session by Thröstur Eysteinsson, Deputy Director

Miles to go...

This year, we celebrate the 100th anniversary of the Law on Forestry and Protection Against Up-Blowing of the Land. Forestry, and in fact soil conservation, had started a few years prior to this law, as part of development assistance from Denmark. For the most part, the Act was drafted by two Danes, a forestry professor and a sand reclamation officer. There was a long chapter on soil conservation in the original draft, which was subsequently omitted by the Icelandic Parliament, with the result that the Act became principally a Forestry Act. It provided for the position of Director of Forestry and under his directorship, forest wardens. The Director also hired a sand reclamation officer, even though it was not stipulated within the Act itself.

For six years, forestry and soil conservation were organised within a single agency, the Forest Service; but in 1914, our ways parted, and since then, forestry and soil conservation have been in separate agencies, sometimes referred to as sister agencies.

For the first half of the 20th century, Iceland was a very poor country and poverty can rightly be seen as at least part of the reason for not having done more to both protect woodlands and curb soil erosion. Though that was the case then, this is certainly not the case now. Yet there is still widespread and active soil erosion, large desertified areas, and Iceland is still the least wooded country in Europe.

Most Icelanders profess to support both increased efforts at soil conservation and increased afforestation. However, although public spending for both has increased in recent years, it has not kept pace with the growth of the Icelandic economy. As a proportion of gross domestic product, we are actually spending less on soil conservation and forestry now than we did ten years ago. We´re doing more, but we are not doing as much as we could, and certainly not as much as we should be doing.

There is no reason to expect that Iceland’s economic situation will continue to flourish as it is doing now. In fact, there is no guarantee that we will not at some point in the future become dependent again on sheep for food and wood for fuel. Those who say that we need an eroded landscape as a tourist attraction or that a few trees will spoil the view are short-sighted. We have the opportunity now to make significant progress in stopping erosion, turning desertification around and reclaiming forest cover. If we do not use this opportunity, then we are behaving not only irresponsibly, but unethically.

Happy Centennial to the Soil Conservation Service from your twin sister. Let us celebrate our achievements of the past century, but let us also use this point in time to renew our determination to do better in the years to come.

In the words of Robert Frost:

The woods are lovely, dark and deep,
But I have promises to keep,
And miles to go before I sleep,
And miles to go before I sleep.

The Farmers Association of Iceland

Address delivered at the Closing Session by Sigurgeir Thorgeirsson, Director[1]

President of Iceland, Mr. Ólafur Ragnar Grímsson; Mr. Chairman; Distinguished guests;

It is an honour for me to be given the opportunity to address this very important Forum and at the same time to forward greetings of congratulation to the Icelandic Soil Conservation Service from the Farmers Association and the farming community, now that this institute commemorates a century of organized land reclamation work in Iceland.

We live in a world of rapid changes, so rapid that it is very difficult to foresee developments, even of the nearest future, not to mention the task of trying to predict what will happen in a decade or so.

But despite all changes and instability, we can rely on one thing, and that is the increasing need of the human race for food. Science will continue to provide us with better knowledge and new technologies to meet future challenges, but we must never forget the fundamental factor in agricultural food production, namely the soil.

At the turn of the 20th century, Iceland was among the poorest countries in the world. Life through the centuries had been a constant battle for survival, a battle fought in physical and cultural isolation against harsh natural conditions. A combination of non-sustainable land use and natural factors had resulted in vast degradation of vegetation and soil erosion.

The pioneers who started the defensive work against the destruction in 1907 faced an overwhelming task with very limited financial means and primitive technology. They were driven by idealistic force and determination, and I think it is true to say that idealism, energy and dedication have forever characterized the leaders of the Soil Conservation Service.

Right from the beginning, there has been close cooperation between the Soil Conservation Service and the Agricultural Society and later the Farmers Association. Clearly, these parties have not always seen things with the same eyes, but on the whole there has been mutual understanding of each other's position.

The Soil Conservation Service has in later years placed increasing emphasis on guidance to those who use the land, and at the same time, farmers have taken over much of the field work involved in reclaiming soil and vegetation. This has proved to be a very successful cooperation, and we expect it to only increase, not least if or when the sequestering of CO_2 from the atmosphere becomes an additional goal in land reclamation.

Finally, I congratulate the staff of the Soil Conservation Service on their one hundred years' history of remarkable success. I congratulate you all on this International Forum, which I am sure has been successful, and I look forward to future cooperation.

Thank you.

[1]Currently with the Icelandic Ministry of Agriculture and Fisheries.

United Nations Development Programme

Address delivered at the Closing Session by Olav Kjørven, Assistant Administrator and Director, Bureau for Development Policy

From Climate and Poverty Crisis to Opportunities for Sustainable Development

President Grímsson, Distinguished Forum Participants, Ladies and Gentlemen,

The global community will have growing difficulties in maintaining food production, achieving water security or meeting greenhouse gas targets without a major improvement in soil management and restoration of land quality. Indeed, improving productivity of the land and making peace with nature is a challenge we must meet if we are to secure equity and prosperity for the human population in the coming decades. The challenges facing us are enormous. Land degradation and desertification have been a key factor in reducing biodiversity, damaging watersheds, increasing hunger and poverty, and upsetting peace in many parts of the world.

The Need for Integrated Solutions for Climate Change and Land Degradation

Interacting with these compelling challenges comes human-induced climate change, one of the most complex, multifaceted and serious threats that humanity has ever faced. Indeed, the United Nations Secretary-General Ban Ki-moon has characterized climate change as "the defining challenge of our age". It is clear that climate change is not only an environmental problem but a defining development and security challenge of our age, interacting with consequences of the vast land degradation and desertification that have taken place in many parts of the world.

We dedicated UNDP's 2007/2008 Human Development Report to climate change and development, to focus attention not on climate change as such, but on the interaction between climate change and human development.

The Report found that the human costs of climate change have been severely understated. While climate change is a threat to humanity as a whole, it is the poor who face the most immediate and most severe costs. In societies that are living in poverty, climate-related risks force people into downward spirals of disadvantage that undermine future opportunities and undermine the achievement of the Millennium Development Goals. The situation is already dramatic.

Let me give you a few examples:

- If the global temperature rises more than 2 °C, we could see an extra 600 million people in sub-Saharan Africa go hungry, over 200 million more poor people flooded out of their homes, and an additional 400 million exposed to diseases like malaria and dengue fever.
- Both Latin America and Africa can expect to see agricultural productivity decrease by 10-20% by 2080, measured against 2000 potential.
- On average, 1 person out of 19 in a developing country will be hit by a climate disaster, compared to 1 out of 1,500 in an Organisation for Economic Co-operation and Development (OECD) country.

Each and every one of these disasters has long-term negative consequences for human development: malnutrition, missed education, life expectancy. We can now trace the consequences decades after a disaster event. These long-term effects have been vastly underestimated in terms of socio-economic consequences.

There are enormous ethical and equity issues here, and an historical issue of responsibility that we cannot escape. About 70% of the heat-trapping gases that we have been busily releasing into the atmosphere over the last 150 years can be traced back to the rich countries. About 28% of the existing stock can be attributed to middle income countries and emerging economies (but growing rapidly), and only 2% to the least developed countries. And yet, the people in these least developed countries will bear the biggest burden and the biggest impact of climate change.

Going back to our concept of human security, climate change will certainly make it harder for people and states to protect themselves from critical and pervasive threats. Increased frequency and severity of droughts and floods will make it harder for people to grow, find or buy food and find safe and affordable drinking water. Already we are hearing from farmers and communities in places like Bangladesh how the soils have simply vanished from their lands after the recent cyclones. Glacial melting in the Himalayas alone will impact water security and options for food production in large parts of Asia in the coming decades in an area that 2 billion people call home. We know that extreme hardship can contribute to violence and conflict. And if people somehow don't resort to violence, chances are they will try to go elsewhere instead. To the cities, or to other countries. Migration will increasingly become a de facto climate adaptation strategy for many. This emerging massive threat to human security is already becoming apparent in many countries around the world.

We live in an insecure world where increasing numbers are threatened by a changing climate and other challenges to livelihoods and security, and excluded from opportunities and protection that should be provided by citizenship.

Interestingly, some of the ways to address the climate crisis have the potential of helping us to address the larger challenges of expanding human security.

The current negotiations on climate change are about the kinds of rules that will govern the behaviour of states, companies and citizens in the future. Now, what does a fair global regime look like? I would venture to say that it must somehow come to terms with the fact that emissions from anywhere have real impacts on people somewhere else.

To put it in stark terms, flying to Iceland for this important Forum, under a global rule of law that has yet to establish a price on carbon emissions, is connected to the poor West Africans throwing themselves onto rafts to escape destitution in their countries. We cannot compensate anybody directly. That will never be workable. But we have to set a global price on carbon. The polluter must start to pay. And significant financing for poor countries' adaptation must be worked into the deal. The rules of the game must change.

Responding to climate change in a rational manner that is underpinned by science offers this generation the opportunity to craft a more sustainable future. It would make major inroads in providing energy access to the poor, protecting forests and biodiversity and improving the efficiency of consumption and production without compromising economic growth and progress in human well-being. We have our first best chance, in a way, to make peace with nature, of reconciling the laws governing man and the laws governing nature, of changing the rules of the game, of creating real win-win opportunities that could potentially yield huge benefits.

A New Development Paradigm?

Climate change interacting with other environmental, economic and social factors will, unless abated through aggressive collective action in the coming decades, throw millions of people currently living above the poverty line into misery and destitution. As a part of remediation strategies we should envision:

- Development as empowerment: expanding opportunities for people to solve their problems;
- Environment as opportunity: solving local and global challenges by tapping environmental resources in innovative ways;
- Combining these two into a new powerful paradigm of sustainable development.

In a carbon-constrained world, cap-and-trade carbon markets linked to mitigating climate change are likely to become an extremely important part of financing such win-win opportunities.

The Kyoto Protocol gave birth to an incredibly exciting experiment, namely market-based mechanisms at the global level to address the sustainable development challenge. The Clean Development Mechanism is an innovation in global public policy of the highest order in the sense that for the first time, degrading a global public good, a stable climate system, would have a price at the global level and the polluter would have to pay for the "license" to pollute by investing in cleaner development in other parts of the world, specifically in developing countries. The Clean Development Mechanism is up and running and is already transferring billions of dollars from the North to the South.

There are many limitations, challenges and problems with the Clean Development Mechanisms in its current form. Not least of which are its limitations in terms of contributing to meaningful poverty reduction and restoration of soil and land quality. Nevertheless, it has succeeded in generating billions of dollars for investments in cleaner and more sustainable technologies in the developing world, derived from carbon as a global public good.

Now the challenge facing us is to successfully negotiate a global deal beyond the current commitment period that will allow carbon finance to really go to scale and more effectively provide part of the answer to the global climate change challenge, while addressing critical development needs for developing countries. The Kyoto experience to date demonstrates that this can indeed be done, but it will require important improvements.

One such improvement is to make carbon finance relevant to all developing countries including the poorer ones and to make it relevant to the fight against poverty.

Creating a Win-Win Situation for Achieving Multiple Goals

Paradoxically, one of the greatest opportunities for making climate change mitigation and related carbon finance relevant for poverty reduction may be in marginal rural areas, as found for instance over vast expanses of sub-Saharan Africa, and in the remaining standing tropical forests around the world.

Much of the land that poor farmers and communities try eking a living out of is severely degraded. According to the IPCC reports, in coming decades the combination of rural poverty, land degradation and climate change will greatly exacerbate the vulnerability of poor communities in Africa and many other parts of the world. Adapting to these circumstances is quickly becoming a major development challenge for the countries concerned and for the global development community.

Similarly, poor communities living in or near tropical forests have limited options for making decent livelihoods in the absence of a conducive policy environment that supports sustainable management and use. They have to compete with logging companies and other economic interests based on quick, unsustainable extraction of lumber, minerals and other resources. They too are left more vulnerable and with even fewer options for survival and development once the forest resources are gone.

Interestingly enough, degraded lands and tropical forest areas are precisely the kind of lands that can potentially absorb large quantities of carbon from the atmosphere, and thus contribute to meeting global goals for reducing concentrations of greenhouse gases.

The kinds of efforts that could bring about such a positive climate outcome are the very same efforts that could make a huge difference in the livelihoods and development prospects of poor farming and forest-dependent communities, and at the same time build greater resilience against the unavoidable effects of climate change: programmes of rehabilitating the fertility and productivity of the degraded lands and programmes to protect standing forests. The question is, why aren't such programmes happening already? One major reason is the lack of development finance available for land rehabilitation, particularly for the initial investments, and the lack of incentives for protecting forests. But at least as important are the many issues and problems related to lack of clear rights to ownership and use of the land and forest resources. Poor farming communities as well as individual farmers are shut out of a working, functional legal order where land and forest rights are secured. Many noble development efforts have in the end stranded due to failure to address this issue. On the other hand, recent successes involving transfer of land and resource rights to local communities and smallholders from many parts of the world point to the fact that a change for the better is possible. For example, in Niger, by transferring ownership rights of trees from the state to local communities in an area the size of Britain, the landscape has been transformed over the last two decades to such an extent that forest cover is back, livelihoods restored and vulnerability to droughts reduced.

Carbon finance could help fuel and accelerate such transformations. With the necessary reforms and improvements in the rules governing this market, land sequestration of carbon could become a major investment area in coming years, as could sequestration in standing tropical forests. In other words, carbon could become part of the financial equation for helping address both climate change and rural poverty. What is more, the market would bring the financing directly to those on the ground in need of investment capital. It is essential to create space in the next round of climate change negotiations for this agenda.

The challenge and opportunity lies in building strong coalitions that can help drive change in all the camps of climate change, land quality, food and water security, and rural poverty. The significant potential of the carbon market should act as an incentive for policy-makers to reform law and practice when it comes to land and forest resource rights for the poor so as to ensure that individual farmers as well as communities can succeed in land rehabilitation and forest conservation and in increasing productivity and incomes. This is not an easy challenge, but it is certainly the best chance seen in a very long time for bringing badly-needed development investments to rural poverty-stricken areas.

I thank you for your attention.

United Nations Framework Convention on Climate Change

Address delivered at the Closing Session by Halldor Thorgeirsson, Deputy Executive Secretary[1]

President Ólafur Ragnar Grímsson, Distinguished guests, Ladies and Gentlemen,

We are gathered here today to celebrate the foresight of the leaders of this island nation when they, in 1907, as they were taking their affairs into their own hands after being a part of the Danish Kingdom for centuries, resolved to fight the loss of soil and vegetation and to reclaim what had been lost. Protecting the soil and vegetation and planting trees has since been an integral part of the effort of this nation to protect and create wealth from its abundant natural resources making it now one of the most successful economies.

The pledge from 1907 was renewed in 1974 when Icelanders celebrated 1100 years of settlement on the island, resulting in a major additional effort to reclaim lost soil, protect the remaining natural forests and plant new ones. Studying biology at the time at the University of Iceland and serving on the editorial board of a publication put out by biology and geology students at the University, I found myself with two or three others visiting a young visionary, Sveinn Runólfsson, director of the Soil Conservation Service in Gunnarsholt. His vision for the future touched us all and had a lasting impact on me. Now, thirty years later, Sveinn is still pursuing his dream.

Now in 2007, the leaders of the world find themselves in a similar situation as the leaders of Iceland did in 1907. The Intergovernmental Panel on Climate Change (IPCC) has put the facts plainly on the table and spelled out in unequivocal terms that mankind has already changed the climate and that current policies will result in unacceptable consequences. The IPCC has also demonstrated that the technological solutions are available and that the worst consequences can still be averted if decisive action is taken without delay. Global emissions of greenhouse gases will have to peak within the next 10-15 years and decrease to half of what they were in 1990 by 2050. I am delighted that Dr. Pachauri is with us and will present the best scientific advice available.

Will world leaders arise to this defining challenge of our times? There are every indications that they will. This imperative has the undivided attention now of world leaders. The Asia Pacific leaders are debating these issues in Sydney this week, and the G8 meeting of the five largest developing countries in Heiligendamm in June 2007 resulted in important outcomes. The Secretary-General of the United Nations has taken the unparalleled step of inviting governments to send high-level representation to New York later this month to debate climate change on the eve of the opening of the General Assembly.

All of this activity and more is focused on finding the way forward when the first commitment period of the Kyoto Protocol comes to an end in 2012. The Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in Bali in December 2007 will need to launch comprehensive negotiations to put a new post-2012 climate change regime in place in time.

The next two years will therefore be critically important in the design of this new regime. The UNFCCC Climate Change Talks that concluded in Vienna last Friday lay the groundwork for this major effort. Countries reassessed the big picture and identified the key building blocks for an effective response to climate change.

The issues that you have been debating in this International Forum are highly relevant in this context. Twenty percent of today's global greenhouse gas emissions come from deforestation. The parties to the UNFCCC will complete in Bali a two-year negotiating process on ways and means to reduce these emissions, including through the emerging carbon market, creating direct economic incentives to conserve forests. This challenge will be a part of the future process.

Adaptation to the impacts of climate change will be one of the key building blocks of the post-2012 regime. These impacts will fall particularly hard on countries already affected by land degradation and desertification, making their efforts to meet their development aspirations all the more difficult. The post-2012 regime will need to provide these countries with ways and means to reduce their vulnerability to current and future climate variability and change. Trees and other vegetation play a significant role in this.

Addressing climate change will need unparalleled global effort. Let us hope that today's leaders will arise to this challenge as the leaders of Iceland did in 1907.

I thank you.

[1]Currently Director, Bali Road Map Support, United Nations Framework Convention on Climate Change.

United Nations University

Address delivered at the Closing Session by Zafar Adeel, Director, UNU-INWEH

Your Excellency, President Ólafur Ragnar Grímsson,

Excellencies, Distinguished Forum Participants, Ladies and Gentlemen:

It is my great pleasure to share some thoughts at this auspicious occasion that celebrates a century of research and successful efforts to meet the challenges of land degradation in Iceland.

This Forum has brought some much-needed focus to land degradation, its impacts on soils and climate change, and consequently the threats to human societies. It is indeed an issue that is of great interest to UNU as an organization.

Over the past few years, it has been increasingly obvious that land degradation is one of the most threatening global environmental challenges. More importantly, our inability to address it adequately threatens to reverse the gains in sustainable development we have seen emerge in many parts of the world. It is a process that can inherently destabilize societies by deepening poverty and creating environmental refugees who can often add stress to areas that may not yet be degraded. Impacts of soil and land degradation are exacerbated by political marginalization of the dryland poor and the slow growth of health and education infrastructure.

We also have mounting evidence that land degradation leads to strong adverse impacts on a worldwide scale. The most common and visible of these impacts are dust storms, typically originating in the Sahara and Gobi deserts and affecting the entire Northern hemisphere. In addition to dust storms, desertification is directly linked to downstream flooding, impairment of global carbon sequestration capacity, and regional and global climate change. These impacts on the natural environment are also linked to societal impacts.

It is also becoming increasingly obvious that our failure as a global community to address this problem partly relates to our inability to formulate effective and successful policies. It is high time that we take action to correct these policy directions and enable developing countries to tackle these challenges through their own scientific research and assessment capacity.

The United Nations University (UNU) has a mission to bridge the divide between the research and policy-making communities in order to address pressing global challenges like desertification. And this is indeed the challenge of today: How can we pull all the strands of this human, social and economic development together in a way that we arrive at success for the people most threatened by land degradation? Addressing land degradation is a critical and essential part of adaptation to climate change and mitigation of global biodiversity losses. UNU has led the argument over the last decade that we must take advantage of such interlinkages in policy formulations.

Ladies and Gentlemen, while we know about and have heard about the doom-and-gloom scenarios, this Forum is about finding a way forward. We have at our disposal today immense human, technological, institutional and even financial resources to overcome this challenge. On the whole, combating desertification and land degradation can yield multiple benefits at local and global levels.

In this context I would like to draw your attention to four joint initiatives in which UNU is taking the lead together with our partners to help mitigate the situation for dryland dwellers.

First, in collaboration with six United Nations agencies, three regional development banks and support from Global Environment Facility, UNU is executing a major initiative to support the evaluation of global environmental benefits achieved through sustainable land management. The initiative, called Knowledge Management from Land (KM:Land), is planning a broad range of regional and global consultations, bringing together project managers as well as sustainable land management experts. In fact, the first of such consultations was held here in Selfoss last week, and we are grateful to our Icelandic colleagues for supporting that exercise.

Second, we are continuing to work with a number of desertification research institutions in Tunisia, China, Syria and Japan to implement an International Master's Degree Programme. Focused on integrated management of dryland resources, it is specifically designed to enhance and mobilize the existing expertise in the region. I am pleased to inform you that the second cohort of graduate students will start this programme next month. One of the graduates of the programme is here at the Forum, and it is encouraging to see her contribution to the science of land degradation.

Third, UNU joined hands with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Centre for Agricultural Research in the Dry Areas (ICARDA), and a number of national partners to implement a comprehensive programme on sustainable natural resources management in marginal drylands. The programme, called SUMAMAD, is implemented in eight countries: China, Egypt, Iran, Jordan Pakistan, Syria, Tunisia, and Uzbekistan. It has helped to bring together a comprehensive assessment methodology for a better understanding of local problems and creation of new livelihoods for local communities.

We are now working with the Government of Iceland to develop an international training programme on approaches to combat land degradation and restore land. This builds on a long history of collaboration to create similar programmes addressing issues related to management of geothermal energy and fisheries. And such a programme will serve well the vast demands for such training in dryland developing countries.

In closing, I would like to express my gratitude to the many partners in this Forum, who have strengthened this event. I am particularly grateful to the Soil Conservation Service for their leadership on this important topic. I trust that the deliberations and recommendations of the participants will help catalyze a sea-change in thinking about land degradation and what it means to us all. I reiterate to you that these international partnerships are critical for overcoming one of the most threatening environmental challenge of our times.

In conclusion, I would like to express my warm gratitude to the hosts in Iceland for the excellent arrangements for this Forum.

Thank you very much for your attention.

United States Department of Agriculture – Natural Resources Conservation Service

Address delivered at the Closing Session by Dana D. York, Associate Chief

Common Ground for 21st Century Conservation

Thank you, your Excellency Dr. Grímsson, for your kind introduction. On behalf of the 11,000 men and women of the Natural Resources Conservation Service, including our agency chief, Arlen Lancaster, let me say how pleased we are to take part in this wonderful celebration. We consider our Icelandic colleagues to be a close professional family and would not miss the opportunity to congratulate you on your many impressive accomplishments.

Iceland's establishment of the first organized Soil Conservation Service a century ago is typical of the many "firsts" which characterize your proud national history, including creation of the world's oldest practicing legislative body, election of the first woman Chief of State, and your pioneering use of renewable fuels as a means to gain energy independence. Through these achievements and others, Iceland's people and institutions have influenced the evolution of democracy and conservation worldwide and have earned both our esteem and our gratitude.

Iceland's historic leadership is just one of the causes for celebration today, however. A second is that in coming together in Selfoss as an international community to discuss our planet's most pressing environmental challenges, we have found common ground from which to begin to resolve them. As we commit ourselves to future cooperation on wide-ranging issues, it is perhaps worth taking some time to revisit a bit of the past.

Soils and Society

Our Forum theme, "Soils, Society & Global Change," could certainly do double duty as the title for a history of US conservation on non-federal lands. Although we began a national programme of soil surveying in the United States in 1899, we did not formalize our Soils Conservation Service – the forerunner of today's Natural Resources Conservation Service – until the mid-1930s, following severe degradation of the American plains during the Dust Bowl era. Failed national policies designed to encourage settlement in the near-west and poor land management decisions taken by individual farmers imperilled our agriculture-based economy and citizens' quality of life. Faced with these threats, soil scientist and agency founder Hugh Hammond Bennett advocated "retracing our steps across the land in an effort to correct past mistakes in the interest of the future" (Bennett, 1939).

Bennett, a visionary sort of fellow, had been laying ground work for the agency well in advance of its creation. He lobbied to establish soil erosion experiment stations and used the results to develop demonstration projects, including conservation plans for participating farms.

But Bennett knew more had to be done, and on a grander scale. He set off on a nationwide speaking tour and went before Congress to ask for additional funding and personnel, but initially without much success. Following a very dark day in April 1935 known as "Black Sunday" because a dust storm in the plains blackened the sky so it looked like midnight at midday, Bennett decided to try again.

Having learned from the weather bureau that detritus from the storm was moving east, Bennett scheduled his congressional testimony to coincide with the duster's predicted arrival in Washington. Here's a description of the meeting from an extraordinary book on this period by Timothy Egan, called *The Worst Hard Time* (Egan, 2006):

"On Friday, April 19, five days after Black Sunday, Bennett walked into Room 333 of the Senate Office Building. He began with the charts, the maps, the stories of what soil conservation could do, and a report on Black Sunday. The senators listened, expressions of boredom on the faces of some. An aide whispered into Big Hugh's ear. 'It's coming.'

So he kept talking.

'Keep it up,' the aide told Bennett again, 'it will be here within an hour, they say.' So Bennett continued, until finally "a senator who had been gazing out the window interrupted Bennett. 'It's getting dark outside.'

The senators went to the window. Early afternoon in mid-April, and it was getting dark. The sun over the Senate Office Building vanished. The air took on a copper hue as light filtered through the flurry of dust. For the second time in two years, soil from the southern plains fell on the capital. This time it seemed to take its cue from Hugh Bennett…

'This, gentlemen, is what I'm talking about,' said Bennett. 'There goes Oklahoma.'

Within a day, Bennett had his money and a permanent agency to restore and sustain the health of the soil."

Two years later, the first local soil conservation district was formed in North Carolina; that district, which includes Bennett's home, just marked its 70th anniversary. Its founding was a watershed moment, so to speak, in the history of soil conservation in the United States, as landowners and the government began to share responsibility for conservation on private lands. Government field offices staffed with expertise appropriate to the needs of the county being served were also set up.

Bennett was convinced of the soundness of this approach: “In this democracy,” he wrote, “national action to conserve soil must be led by these millions of land users. If they are active and willing participants in such a movement, it will endure; otherwise it will fail.” (Bennett, 1939). He also thought participation in our programmes should be entirely voluntary, which it has been to this day.

He was right, of course, about the importance of bringing society and soil science together. Today, there are more than 3,000 conservation districts nationwide which coordinate federal, state, local and private assistance to enable landowners to put conservation on the ground. As a result of this insightful construct, delivery of conservation programmes is connected from policy-makers and funding sources in Washington, DC all the way to individual farmers and ranchers well outside the nation’s capital – tailored, moreover, to their specific resource needs and those of the community at large, ultimately providing benefits to all citizens.

More than two-thirds of land in the continental US is in private hands. That equates to more than 1.4 billion acres. Thus, the marriage of local leadership and national objectives has been, and remains, critically important in effecting lasting change for the environment, whether on a single acre or across a landscape. It has also afforded flexibility in programme implementation over the years as science has progressed, funding has ebbed and flowed and particular regions or resource concerns have become greater or lesser priorities.

What began as a fairly narrowly-focused mission set emphasizing soil health has grown into a broader family of authorities, programmes and strategies supporting high-quality, productive soils, clean and abundant water, and healthy plant and animal communities.

What Have We Learned, Then?

In my effort to compress 70 years of activity and policy-making into several minutes, I have perhaps made delivery of our conservation programmes to private landowners appear seamless or without controversy. There have certainly been challenges along the way and periods during which some believed the demand for agricultural production would overwhelm our stated national commitment to conservation; there were times we wondered whether we could have hugely productive lands and a healthy environment. And we have certainly learned many lessons; I’d like to share a few of them with you.

First and foremost, we now generally accept agricultural production and environmental quality as compatible national goals and for more than 20 years have expressed that symbiosis through legislation and appropriations informally referred to as “Farm Bills.” This legislation expires every five to seven years. An array of 2007 Farm Bill proposals are currently under consideration by members of the US Congress.

For the most part, the funding and authorities resulting from recent Farm Bills have supported abundant production while also increasing our capacity to get conservation on the ground.

However, it is important to understand that conservation technical assistance, which is our agency’s oldest programme and which we consider “the engine of conservation” (Helms, 2005), is authorized and funded outside Farm Bill legislation. Most often, when we talk about our mission of “helping people help the land”, we mean providing technical assistance.

More recently, though, we have begun offering financial as well as technical assistance to farmers and ranchers and this has become an increasingly large part of our workload, especially during the last five years. While there can be no doubt that financial incentives facilitate adoption of conservation practices, it is technical assistance that makes them feasible and effective.

So, a second lesson is that financial assistance programmes, whether delivered in the form of cost-share programmes, easements, grants or stewardship payments, can distract us from core planning and other mission-essential activities. And the more specialized these programmes become, the more difficult they are to absorb into our existing administrative and operational structures. We continue to struggle with finding the right balance in delivering technical assistance and financial assistance.

Further, as the number of financial assistance programmes has grown, so has landowners’ and partners’ confusion, given that there are sometimes only slight variations in programme purposes or payouts, but often widely differing eligibility rules.

These are some of the reasons why agricultural producers told us the 2007 Farm Bill should: simplify and consolidate conservation programmes, for us and our customers; significantly increase conservation funding; support emerging priorities, such as renewable energy research; and, provide direct benefits to beginning farmers and ranchers and socially disadvantaged producers. These proposals are reform-minded, for programmes that are merit-based and market-oriented, to enable us to meet future challenges, to make conservation easier and to be more transparent in our business practices. How and if these proposals will be captured in final legislation is anyone’s guess as we still have a long way to go.

I do want to make one final point about the process, though; most years, as the draft legislation makes its way through congressional committees, it typically does so without much notice. This year is proving to be an exception to that rule, as urban taxpayers, organic growers and environmental organizations have tuned into the debate and aren’t hesitating to voice their opinions. When President Abraham Lincoln founded the US Department of Agriculture in 1862, he did so saying it was to be “the People’s department.” This year, “the People” are making sure their concerns and preferences are heard.

Global Change and the Future

So why is this year different? I'd suggest it's because citizens are riding the crest of the burgeoning environmental wave that has been building worldwide for decades. Voters' active engagement in the Farm Bill process reflects increasing interest everywhere in issues like global warming, food safety and sustainable resources management, among others. They have educated themselves about the linkages between soil degradation and other large-scale environmental problems and they expect their neighbours and leaders to understand them, as well. It makes sense to them that if environmental problems are linked, the solutions probably are, too.

Then what does this global change mean to us as scientists, planners, business people and policy-makers? In short, I believe it empowers us to boldly break new ground for conservation, to go beyond "simply retracing our steps across the land" as Hugh Hammond Bennett said 70 years ago.

But to break new ground, we will first have to break a few paradigms. For instance, in its 2007 assessment of 50 years of soil conservation policy in Europe, the Joint Research Centre of the European Commission noted that "soil protection policies are established when there is a perceived threat to the population" (Montanarella, 2007). This was clearly the case last century in the US and Iceland, as formation of both countries' soil conservation services happened only after threats to lands and peoples became imminent.

But being reactionary in this way will not get us where we want and need to go. We must discipline ourselves to use the powerful tools and expertise at our disposal to think and act more strategically. This is easier said than done in the United States at least, where our funding is allocated annually and we experience the disruptions of elections every few years; but, whenever we can take the longer view, we should.

Wouldn't it be better to improve our current capacity to analyze and weigh the possible outcomes of proposed industrial, agricultural and conservation practices in order to plan more extensively, make better decisions up front and manage risk more responsibly at the outset?

We are already moving in this direction in the United States, under an umbrella programme called the Conservation Effects Assessment Project, or CEAP. With greater government-wide emphasis on measuring performance and as a result of increased scrutiny following substantial funding increases for conservation programmes in the 2002 Farm Bill, we knew we had to strengthen the science base for conservation spending.

CEAP promotes cooperative conservation, including with international partners, since impacts across a watershed cannot be judged in isolation and various parcels of land don't recognize the "public-private" and nation/state labels we assign to them. Establishing a framework for measuring and reporting the full suite of ecosystem services provided by conservation practices is another programme objective; soon, we will be inviting farmers and ranchers to participate in an on-line greenhouse gas reporting registry. Our ability to calculate the amount and value of such services will be paramount as we explore market-based opportunities to encourage investment in conservation.

We know we must also break new ground in how we deliver technical assistance, because our customer base is changing along with technology.

When I joined the Soil Conservation Service 30 years ago, we were taught there is only one way to deliver technical assistance: in person. Yet we have new customers who are only part-time farmers and ranchers, having bought rural properties mainly for recreation. They still desire information, but they want to access it via the internet, late at night or on weekends.

As rural communities acquire broadband and other high-speed communications capabilities, more of our traditional customers are computerizing their operations. So, we must find ways to make virtual services work for both of these groups and our other conservation partners.

We currently conduct soil surveys and other assessments on the web, provide on-line "energy estimator" management tools, and offer both our plants database and field office technical guides electronically, to name a few of our e-initiatives.

Maps and tables for more than 2,300 soil surveys can also be accessed for free on the internet, as can the results of National Resources Inventories, which report on land use and natural resource conditions and trends on US non-federal lands. We have made a good start, but have a long way to go; and, we will need to continuously update and adapt our electronic outreach as technologies change.

But we recognize that we also have other new customers, including some beginning farmers and ranchers, disadvantaged producers and underserved community members who very definitely require the hands-on, in-person technical assistance I spoke of earlier.

How all of us choose to balance the needs of people with the lure and genuine benefits of new technologies will characterize our governments, agencies and partnerships in the 21st century.

As we work to find common solutions for common problems, we must take care to leverage the learning of others. We should, for example, adopt international standards for soil science and surveys and conservation engineering to facilitate information exchange and technology transfer; from the US perspective, we have a lot to bring to the table in those discussions.

But in other areas, such as renewable fuels, we are still building national consensus regarding the way ahead. But we are not discouraged, because we are confident that we can learn much from others' research and practices, including Iceland's far-reaching, energy-related initiatives. We look forward to hearing more about that from you, Your Excellency, when you deliver the "Frontiers of Soil Lecture" at the 100th Anniversary Celebration of the American Society of Agronomy in New Orleans, Louisiana, later this year.

In Closing

Clearly, it will take a balanced approach, continued aggressive information exchange and technology transfer, and much innovation to ensure we realize the promise of our common ground for 21st century conservation. But there can be no question that we must make the effort, for as the poet and farmer Wendell Berry assured us, "The care of the earth is our most precious and most worthy and, after all, our most pleasing responsibility. To cherish what remains of it, and to foster its renewal, is our only legitimate hope" (Berry, 1977).

Thank you again for including me in this very special gathering. Please plan to join us in 2010 when we celebrate our 75th anniversary in Washington, D.C. I hope to see you there!

References

Berry, Wendell, 1977. *The Unsettling of America: Culture and Agriculture*. Avon Books, New York, NY.

Bennett, Hugh Hammond, 1939. *Soil Conservation*. McGraw-Hill Book Co., Inc., 337 pp.

Egan, Timothy, 2006. *The Worst Hard Time*. Houghton Mifflin Co., Boston, MA.

Helms, J. Douglas, 2005. "Technical Assistance – The Engine of Conservation" in *Historical Insights* Number 5, USDA Natural Resources Conservation Service, Washington, D.C.

Montanarella, Luca, 2007. "Historical Overview on Soil Protection Policies in the European Union (1952-2006)" in *SETAC Europe Annual Meeting 2007*. European Commission/Joint Research Centre.

Forum Plenary

Session 1: Setting the Stage: Soils, Society and Global Change – Global and Local Perspectives

Soils and the Living Earth

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Introduction

Soils are dynamic and immensely variable resources. Soils can be thought of as an active chemical factory, full of life, but various organic substances and clays are among the products of the factory. These products are important in providing the soils with the properties that make them a natural resource, such as water and nutrient storage and release. Soils are fundamental for the Earth's food chain, and it is often overlooked that a higher number of living species exist underground than above the surface. Furthermore, there is more carbon in soils than in plants and the atmosphere combined. A substantial share of the elevated CO_2 levels in the atmosphere is caused by anthropogenic release of carbon from soils due to their utilization. Therefore, soils play a fundamental role in both biodiversity and global climatic change.

Do soils rejuvenate naturally when damaged? Soil formation can certainly balance losses by erosion to a certain degree. However, huge soil losses in one place may have less effect than a slight soil removal from shallow soils on hard bedrock. Young and often fertile soils characterize active geologic surfaces, such as flood plains, mountains and volcanic regions and they are often resilient to human pressure. More mature soils characterize the plains of the tropics and they are often less fertile than soils of the temperate regions. The fertility of the soil is interlinked with other environmental factors such as climate and vegetation cover – and the effect of man. But the severity of soil losses differs from place to place, making generalizations difficult and often misleading.

When addressing the state of Earth's global soil resources, it is important to understand the main functions of soils and ecosystem services in order to come up with meaningful methods for assessing their state, using transparent methods and well defined concepts. This is not an easy task and there are both successes and failures in attempting to assess the state of soils, locally, nationally as well as globally. The aim of this paper is to provide an insight into threats to soil resources, land degradation processes, and discuss the state of the world resources and limitations to global soil condition assessments.

1. Threats to Soils and Causes of Land Degradation

1.1. Processes – condition – land use – root causes

With an ever increasing population, pressure on soil resources is causing damage to soils at an accelerating rate. There are numerous threats to the welfare of soil resources. These include direct soil losses by erosion, salinization, losses of soil fertility (physical, chemical and biological properties), soil sealing from construction, pollution, losses of vital functions and/or elements of the soils such as water storage capacity and biological function. There are many 'off-site effects' associated with soil erosion and land degradation such as siltation of rivers and lakes, dust pollution, contamination of waters and oceans, increased frequency and severity of both flooding and landslides, loss of biodiversity, and increased CO_2 release to the atmosphere. One important aspect of global change is that thawing of permafrost soils releases huge reserves of CO_2 from the Arctic carbon stock (e.g., Stokstad, 2004).

It can be stated that increasing soil degradation is mainly caused by man-induced pressure on land resources. Expansion of agriculture needed to sustain the growing population is predicted to cause unprecedented ecosystem change and degradation of ecosystem services (e.g., Tilman et al., 2001). It is very important to differentiate between i) degradation processes, ii) the land use causing these problems, and iii) the root causes driving the current land use responsible for the problems. The current user may not be causing the problem, however, may be maintaining poor conditions. The root causes of degrading land use may be economical, poverty, land tenure systems, local and regional politics, subsidy policies, and global trade, to name a few root culprits that drive land use that causes degradation. These root causes need to be addressed to alleviate the effects of land degradation and desertification. The monumental Millennium Ecosystem Assessment (2005) has special sections addressing drivers of ecosystem change, which are identified, classified and their effects studied, using spatial scales (global, sub-global, regional, national and local). Demographic, economic, and socio-political drivers are examples of categories identified for the sub-global scale in the Millennium Ecosystem Assessment (2005). Socio-economic factors were also emphasized in a review of soil erosion science by Boardman (2006). The Desertification Synthesis of the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) cites i) social, economic, and policy factors; ii) globalization, and iii) land use patterns and practices as major causes of desertification. They note that "global trade regimes and linked government policies influence food production and consumption patterns significantly and affect directly or indirectly the resilience of dryland ecosystems". Interestingly, they cite land use last in their list. Land degradation processes need to be understood to seek sociological, economic and political solutions. The solutions in the developing countries may often be trade agreements that reduce pressure on marginal lands and reduce poverty. It is also important to note that solutions can be very different between the developing and industrial countries. Several attempts have been made to create helpful models for understanding land use relationships, the DPSIR (Drivers, Pressure, State, Impact, Response) being the most commonly cited model. The European Union – Soil Conservation and Protection in Europe (EU-SCAPE) group developed a simple model, a Sustainability Index Model, that encompasses the relationships between processes and land condition, land use and root causes and is relatively simple to relate to socio-economic drivers (Arnalds, 2005; Imeson et al., 2006).

Natural processes are often stressed as major causes of land degradation, most often climatic fluctuations, spells or events. It is, however, important to bear in mind that most ecosystems are naturally resilient and tolerant to such stresses unless land use has damaged their resilience. Such damage to ecosystem resilience may have occurred in the past, but is not due to current land use.

1.2. The desertification conceptual problem

It is important to understand basic ecological concepts and pathways of land degradation. Understanding of such concepts as resilience and tolerance are often missing in reports and conclusions about desertification. The infamous "marching desert" debate is a good example (see e.g., Force, 1989). The Sahara desert appeared to be expanding > 15 km each year during in the early 1970s, but when the drought ended, vegetation returned naturally (see also Rhodes, 1991). Did the area become more degraded at all? And did the scientific discussion consider earlier degradation and losses of ecosystem resilience and services? The answer is no in at least many cases. This debate is an example of a "one-dimensional" approach (vegetation vs. no vegetation), while both ecological factors and more long-term vision of ecological functions (such as water holding capacity) and degradation processes in the past and future was needed. This "one-dimensional" approach to desertification science resulted in part in the controversial definition of desertification used by the UNCCD. This definition is limited to rainfall conditions ("climate regimes", or "aridity index") rather than what happens to water in ecosystems, or addressing all severe land degradation that affects human livelihood and the effect on sustainability. The Aridity Index merely describes one function related to the ecosystem and is helpful as such, but is only one piece of a larger picture. It is interesting to note that the term 'desert' originally means abandoned land (see e.g., Arnalds 2000). Desert ecosystems are not necessarily formed by desertification and can be relatively rich ecosystems. Humid deserts can be extremely poor as a result of degradation (desertification). These contrasts are well expressed by Icelandic desert ecosystems, which include both humid and dry deserts in terms of rainfall, both natural and as a result of human-induced desertification, but all with similar ecosystem functions. Another example is that severe desertification occurs in many mountainous areas such as Nepal, regardless of climate. The term 'desertification' as it is commonly used, mixes the concepts of ecosystems, (biome, usually vegetated but also often with little vegetation), vegetation cover (barren – dry or not), climate ('arid', but various definitions), processes (multiple degradation processes cause desertification), pressures (drought, land use), and perception (multiple perception such as desolate, abandoned, barren or dry). The key issue should be that all kinds of marginal lands are susceptible to severe land degradation that can lead to reduced productivity of the land and ultimately abandonment, – i.e. desertification.

Figure 1. Which of the two pictures shows a desert? Which one has become desertified? Left: Desert in the western USA, with considerable vegetation cover in an arid region. Right: A desert surface in Iceland, in a cold-temperate humid climate, desertified in the sense of becoming a desolate and unproductive area, where soil water and nutrients are limiting, while unstable surface and erosion processes also contribute to maintaining a barren surface.

Another example of a one-dimensional approach to degradation assessment is using yields as the sole indicator of land condition, as sustainability and other ecological services may be more important for many locations. Fertilizers input can, in fact, mask the long-term effects of degradation by resulting in sufficient yields in spite of severe degradation (Eswaran et al., 2001).

Climate change, land degradation and socio-economic factors are often interlinked, resulting in complex cause-effect relationships (e.g., Dale, 1997). Large scale land degradation is also known to affect climate patterns, which can further intensify pressure on land. There is no doubt that the UNCCD is quite important for the global community and the National Action Plans have great beneficial effects. The UNCCD definition, scientific structure of the Convention (lack of independent panel such as the IPCC for UNFCCC) and other issues are, however, still being debated (e.g., Arnalds, 2000, 2005; Eswaran et al., 2001; Reynolds and Stafford Smith, 2002) and this has a negative effect, both on the Convention and on general efforts to address severe land degradation globally, by restricting the development of a truly global forum for severe land degradation.

2. Assessment – Methodology and Methodological Problems

2.1. Assessing what?

Considering the numerous threats to soil resources and processes of land degradation, it is often difficult to determine which methods are appropriate for assessing the state of soils for any given set of conditions. Site, national and regional differences also make general assessments on the state of the Earth's soils difficult to make. It is therefore obvious that no single method is appropriate for all conditions (see also Lal et al., 1998). Many methods have relied on vegetation cover, which has the benefit of being easily analyzed from aerial photography such as satellite images (see e.g., Bai and Dent, 2006). Soil erosion can be measured at the field plot scale on the ground and models have been developed to calculate erosion quite effectively for agricultural lands. The Universal Soil Loss Equation (USLE) and the Wind Erosion Equation and their derivatives or relatives are the most commonly used. These kinds of models, coupled with landscape analysis, rainfall and other environmental data, have been used to produce erosion risk maps at the regional scale, particularly in Europe (the CORINE project and the EU PESERA; e.g., Grimm et al., 2002). The models put a quantitative estimate to soil losses and the response value is usually tonnes of soil lost from a hectare each year (t/ha/yr). Other methods which are often used for rangeland conditions employ vegetation indices and erosion signatures to assess rangeland condition. These are often based on grading, using 4-6 condition classes or something similar, from excellent to very poor or slight to very severe, to give some examples. It should be noted that it can be disputed where the t/ha/yr response value is the appropriate measure of erosion. Low values (t/ha/yr) can have devastating consequences on shallow soils, but little effect elsewhere. The use or the misuse of USLE has been criticized by many and Boardman (2006) specifically noted that while major erosion is event driven, where there is lack of vegetation cover, the models such as the USLE deal with average conditions. Boardman (1998) has also contested the use of soil erosion rates derived with such models (t/ha/yr response value) for arriving at averages for large areas, as it "distracts attention from the real issue: rates of erosion and associated on-farm and off-farm costs are high in some areas and not in others."

There is a need to differentiate between types of land use when assessing land degradation. It is especially important to differentiate cropland from rangeland and forest when assessing land condition. It is also important to analyze the suitability of cropland for a given production, and not only from the conservation/degradation perspective, but also in light of socio-economic factors, sustainability, environmental costs and societal benefits (Arnalds, 2005).

Productivity is a commonly cited value for assessing land degradation (e.g., % reduction per given time period) and has the benefit of allowing for an estimation of annual losses in revenues (e.g., in $ per year). Lack of productivity can often be masked by direct inputs such as with fertilizers and/or improved technology, which complicate estimates of this kind, and can also give a false sense of security (Eswaran et al., 2001). However, these estimates are extremely important, especially for portraying the damage in terms that many sectors of society can relate to. When applying such methods, it is nevertheless difficult to take other environmental factors into consideration, such as effects on hydrological cycles, flooding, carbon storage, biodiversity, wildlife and aesthetic values.

2.2. Terms of reference and the time factor

When assessing condition of the land, explicit term(s) of reference is needed. But due to the multi-factorial function of soils and ecosystems, this is difficult to achieve. The time factor is also often overlooked: the present state of land may reflect degradation that occurred a long time ago, measured in decades (e.g., USA,) in centuries (USA, Northern Europe, including Iceland), and millennia (China, Mediterranean, West and Central Asia). In some cases, the land resources can be restored, even long after degradation, but reference to the ecosystem condition tends to be more short-term and areas that were severely degraded a long time ago are often considered in normal conditions.

2.3. Major global assessment efforts

There have been some attempts to review data on global degradation, and important overviews include those published by Eswaran et al. (2001), Lal (1990), and Pimentel et al. (1995). There is also an important review published in the Millennium Ecosystem Assessment, (Dryland Systems, Adeel and Safriel, 2005). There are primarily two major global overviews of land degradation, by Dregne and Chou (1994) and FAO/UNEP/ISRIC (GLASOD, e.g., Oldeman and Lynden, 1997, see also GLADA, 2007). UNEP had previously surveyed desertification problems (UNEP, 1991) globally. The Millennium Ecosystem Assessment attempts to take these and other estimates to come up with more up-to date estimates. These efforts are of immense importance to obtain a global overview of soil degradation. However, they are coarse grained surveys with many limitations. Lal (2004) concluded that the literature on global soil degradation was "replete with gross extrapolations based on scanty data, often outside of eco-regions from which data were obtained." In his review, Boardman (2006) also stressed the need for an update to the scientific approach at the global scale. There is ample room for large improvements in this area of science.

3. State of Soil Resources

What is the state of Earth's soil resources? The world's landmass is about 130 million km^2. A large part of this area is marginal, such as dry, arctic or mountainous areas. Grazing area is considered to be 40-60 million km^2, forests to be 40 million km^2 and about 15 million km^2 to be cultivated. Dryland zones are about 40-60 million km^2, depending on definitions, but are only partly the same as those defined as grazing areas. Published global figures on how much land is affected by degradation vary almost by order of magnitude, or from 10-70% of Earth's drylands. Dregne and Chou (1994) report 70% of dry areas as degraded, a total of about 40 million km^2. Oldeman (1994) reports water erosion as the most extensive degradation process, with a considerably lower extent of degradation (19.7 million km^2 light to extreme, 12.1 million km^2 moderate to extreme). The Global Assessment of Human Induced Soil Degradation (GLASOD) (Oldeman and van Lynden, 1997) cites 11.4 million km^2 degraded within the drylands and 19.6 million km^2 worldwide. They also cite that 1.4 million km^2 has severe and extreme severe degradation. Eswaran and Reich (1998; quoted in Eswaran et al., 2001) estimated that "CCD areas" that have "high to very high desertification" are about 15 million km^2, and all dryland areas affected by water erosion were 23 million km^2 and wind erosion 17 million km^2 (these areas presumably partly overlap). The Millennium Ecosystem Assessment (2005, Chapter 22 on Drylands) reaches different conclusions on the extent of land degradation by stating that 10-20% of the world's drylands suffer from one or more forms of land degradation, but noted many difficulties in reaching their conclusions. The difficulty in obtaining reasonably accurate global estimates of this kind and their limitations should be fully appreciated. The estimates give an indication by order of magnitude, and the results are truly confounding.

The present author has additional reservations to those pointed out by the Millennium Ecosystem Assessment (2005) and Lal (2004) regarding estimates of this kind, especially the terms of reference and time scale. Increased production in a given area compared to what it was some decades ago does not mean that the system is not severely degraded if a longer time scale is used as reference. Many of the areas under consideration are truly quite degraded if centuries or millennia are used for reference, e.g., the Mediterranean and other areas (see above). Furthermore, it is often stated that soil takes thousands of years to form, but perhaps that statement is more valid for the development of certain soil features, such as clayey subsurface Bt horizons, which in turn only partly explain the fertility of a given soil. A single publication may report much improved production within decades, contradicting its own introduction remarks on non-renewable soil resources. It should also be noted that under many conditions, previous fertility of soil can be attained much earlier than many well-developed soil features (e.g., on loess parent materials and flood plains), and the degraded state can be masked by fertilizer applications.

Productivity loss estimates vary as much as estimates of degradation and soil erosion. The effect of erosion on productivity is very site specific, ranging from 0 to >90% reduction. It is quite difficult to make such estimates on a global scale, unless there are thorough definitions of variables and qualifiers used in such modeling. Among important factors is the time of reference, as was previously mentioned for degradation estimates (year, decade, century, millennia). Rattan Lal and coworkers and several other groups have made notable calculations of productivity losses and costs of erosion for countries and continents, as reviewed by Eswaran et al. (2001). Revenue losses in the US alone are estimated at US$ 44 billion and Eswaran et al. (2001) concluded that on a global scale, the annual losses due to soil erosion are about US$ 400 billion. This is a staggering figure and does at least give an indication of the costs of land degradation in the world. Costs of remediation are not included in these figures, and other environmental costs associated with land degradation, such as increased flooding. Release of CO_2 from soils because of land degradation can also amount to immense costs, considering current carbon trade values. Furthermore, one can hardly put such a numerical figure to the poverty and harm caused by displacement of people and even war caused by degradation of natural resources. It is often cited that more than 1 billion people are at risk because of desertification (presumably limited to UNCCD desertification areas). The risk concept relates to the future. A figure such as one billion people is bound to become much too low an estimate when the population of the Earth has doubled in the not too distant future.

Discussion and Conclusions

Many have pointed out the necessity to clarify conceptual problems associated with desertification research and politics. Reynolds et al. (2003) noted that "there is an urgent need to lessen uncertainties that paralyze action and for new thinking beyond regional and disciplinary concerns". Eswaran et al. (2001) noted that: "Land degradation remains a serious global threat but the science concerning it contains both myths and facts. The debate is perpetuated by confusion, misunderstanding, and misinterpretation of the available information." The very concept of desertification has been questioned by many, as it is used by the UNCCD (see section above). Many have suggested new methodology to cut through the confusion and complexity of desertification science (e.g., Reynolds et al., 2003, Bergkamp, 1995), asking for or suggesting new paradigms (e.g., Reynolds and Stafford Smith, 2002; Geeson et al., 2002; Adeel and Safriel, 2005). It is likely that such a paradigm shift is imminent as there is much research under way that relates to the assessment of degraded lands and restoration. Restoration ecology is currently one of the fasted growing sub-disciplines of the ecological sciences (Young et al., 2005).

In spite of the fundamental importance of the soil resource, it is not adequately cared for in international conventions or law, and rarely in national legislations. The US National Research Council (cited in Doran and Jones, 1996) noted that "Protecting soil quality, like protecting air and water quality, should be a fundamental goal of national environmental policy". Recent developments in many European countries and the EU, with the development of a new Soil Protection Directive, may signify a change. However, because of limitations of the UNCCD, it seems necessary to develop a new UN convention for soils and land degradation.

While it is important to understand the ecology and processes of degradation, it is also vital to understand the socio-economic drivers for the problems and for potential solutions, not merely actions on the ground (see section 1.1. above). Actions on the ground will also have to consider long-term restoration, not short-term economic benefits or merely plant cover (e.g., by using invasive plant species and one-dimensional science approaches, see above). Root causes as drivers of present land use may be traced to subsidies (e.g., in Europe and other industrialized countries). Root causes in developing countries can in part be related to subsidies and trade barriers on agricultural products in industrialized countries, and to global trade in general. These considerations merit much further research on a global scale, and political attention.

It is concluded that much of the land on Earth has degraded soils. Time of reference is a confounding parameter for global assessment methods. Much of this degradation occurred millennia ago (e.g., Mediterranean Europe, Asia, Africa, China), but some of this ecosystem potential can be restored. However, there is severe degradation occurring still today, which is intensified by ever increasing population, which is likely to cause ecosystem damage at a scale never experienced before in human history. Finally, there is an urgent need to develop stronger synergies between sciences and actions on the ground related to climate change mitigation, conservation and restoration of biodiversity, desertification prevention and restoration of degraded lands.

References

Adeel, Z, and U. Safriel (lead authors), 2005. "Dryland Systems" in (eds.) R. Hassan, R. Scholes, and N. Ash, *Millennium Assessment, Ecosystems and Human Well-being. Volume 1: Ecosystems and Human Well-being: Current State and Trends.* Island Press, Washington, USA. pp. 623-664.

Arnalds, O., 2000. "Desertification: An Appeal for a Broader Perspective" in O. Arnalds and S. Archer (eds.), *Rangeland Desertification*. Kluwer, Dordrecht, The Netherlands, p. 5-15.

Arnalds, O., 2005. "Knowledge and Policy Making: Premises, Paradigms and a Sustainability Index Model" in *Strategies, Science and Law for the Conservation of the World Soil Resources,* Agricultural University of Iceland, Publication No 4:251-259.

Bai, Z.G. and D.L. Dent, 2006. *Global Assessment of Land Degradation and Improvement: Pilot Study in Kenya*. ISRIC Report 2006/1, Wageningen, The Netherlands.

Bergkamp, G., 1995. "A Hierarchical Approach for Desertification Assessment" in *Environmental Monitoring and Assessment,* 37:59-78.

Boardman, J., 1998. "An Average Soil Erosion Rate for Europe: Myth or Reality?" in *Journal of Soil and Water Conservation*, 53:46-50.

Boardman, J., 2006. "Soil Erosion Science: Reflections on the Limitations of Current Approaches" in *Catana,* 68:73-86.

Dale, V.H., 1997. "The Relationship Between Land-use Change and Climate Change" in *Ecological Applications*, 7:753-769.

Dregne, H.E. and N.T. Chou., 1994. "Global Desertification Dimensions and Costs" in H.E. Dregne (ed.), *Degradation and Restoration of Arid Lands*. Texas Technical University, Lubbock, Texas.

Eswaran, H., R. Lal and P.F. Reich, 2001. "Land Degradation: An Overview" in Bridges, E.M., I.D. Hannam, L.R. Odeman, F.W.T. Pening de Vries, S.J.. Scherr, and S. Sompatpanit (eds.), *Responses to Land Degradation. Proc. 2nd International Conference on Land Degradation and Desertification*. Khon Kaen, Thailand. Oxford Press, New Delhi, India.

Force, B., 1989. "The Myth of the Marching Desert" in *New Scientist*, February 4, 1989, 31-32.

Geeson, N.A., C.J. Brandt and J.B. Thornes, 2002. *Mediterranean Desertification. A Mosaic of Processes and Responses*. Wiley, Chichester, UK.

ISRIC World Soil Information: *Global Assessment of Land Degradation and Improvement (GLADA)*, http://www.isric.org/UK/About+ISRIC/Projects/Current+Projects/GLADA.htm, (Accessed 24 August 2007).

Grimm, M., R. Jones and L. Montanarella, 2002. *Soil Erosion Risk in Europe*. EC Joint Research Centre, EIR 19939 EN, revised. Ispra, Italy.

Imeson, A., O. Arnalds, L. Montanarella, A. Arnouldssen, L. Dorren, M. Curf and D. de la Rosa, 2006. *Soil Conservation and Protection in Europe (SCAPE). The Way Ahead*. European Soil Bureau, Ispra Italy.

Lal, R., 1990. "Soil Erosion and Land Degradation: The Global Risks" in R. Lal and B.A. Stewart (eds.), *Land Degradation. Advances in Soil Science*, 11, Springer-Verlag, New York, pp. 129-172.
Lal, R., W.H. Blum, C. Valentine and B.A. Stewart, 1998. "Methods for Assessment of Soil Degradation" in *Advances in Soil Science*. CRC press, Boca Raton, Florida.

Lal, R., 2004. "Global Extent of Soil Degradation and Desertification" in R. Lal, T. M. Sobecki, T. Livar, and J. M Kimble, *Soil Degradation in the United States*. Lewis Publishers, CRC, Boca Raton, Florida, pp.23-29..

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Desertification Synthesis*. World Resources Institute, Washington, D.C.

Doran, J.W. and A.J. Jones, 1996. "Preface" in *Methods for Assessing Soil Quality. Soil Science Society of America Special Publication*. Madison, Wisconsin, USA, pp. xi-xiii..

Oldeman, L.R., 1994. "The Global Extent of Land Degradation" in D.J. Greenland and I. Szabolcs (eds.), *Land Resilience and Sustainable Land Use*. CABI, Wallingford.

Oldeman, L.R. and G.W. J. van Lynden, 1997. "Revisiting the GLASOD Methodology" in R. Lal, W.H. Blum, C. Valentine, and B.A. Stewart (eds.), *Methods for Assessment of Soil Degradation. Advances in Soil Science*. CRC Press, Boca Raton, Florida, pp. 423-440.

Oldeman, L.R., R.T.A. Hakkeling and W.G. Sombroek, 1992. *World Map of the Status of Human-induced Soil Degradation: An explanatory Note*. ISRIC, Wageningen, the Netherlands.

Pimentel, D, C., P. Harvey, K. Resosudarmo, D. Sinclair, M. Kurz, S. McNair, L. Crist, L. Shpritz, R. Fitton, R. Saffouri and R. Blair, 1995. "Environmental and Economic Costs of Soil Erosion and Conservation Benefits" in *Science* 267 (February 25):1117-1123.

Reynolds, J.F., D. M. Stafford-Smith and E. Lambin, 2003. *Proceedings of the VIIth International Rangelands Congress.* Durban, South Africa, pp.2042-2048.

Reynolds, J.F. and D.M. Stafford Smith, 2002. *Global Desertification. Do Humans Cause Deserts?* Dahlem Workshop Report 88, Dahlem University Press, Berlin.

Rhodes, S.L., 1991. "Rethinking Desertification: What do We Know and What Have we Learned?" in *World Development*. 19:1137-1143.

Stokstad, E., 2004. "Defrosting the Carbon Freezer of the North" in *News, Science*, 304 (June 11): 1618-1620.

Tilman, D., J. Fargione, Wolff, C. D'Antonio, A. Dobson, R. Howarth, D. Schindler, W. H. Schlesinger, D. Simberloff and D. Swackhamer, 2001. "Forecasting Agriculturally Driven Global Environmental Change", *Science* 292 (April 13): 281-284.

UNEP, 1991. *Status of Desertification and Implementation of the United Nations Plan of Action to Combat Desertification*. UNEP, Nairobi, Kenya.

Young, T. P., D. A. Petersen, and J. J. Clary, 2005. "The Ecology of Restoration: Historical Links, Emerging Issues and Unexplored Realms" in *Ecology Letters* 8:662-673.

Global Land Degradation: State, Risks and Prospects under Global Change

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Introduction

Thanks mainly to the United Nations Convention to Combat Desertification (UNCCD), not only desertification (defined as land degradation in the drylands), but also land degradation in the non-drylands has become an issue of mounting interest and concern in both the academic and political arenas. This paper addresses the issue of land degradation's globality with respect to two manifestations of global change, globalization and climate change, and explores how they may jointly put lands at risk of being degraded, while also generating some bright prospects for the inhabitants of drylands.

1. Is Land Degradation Global? The Global Occurrence Criterion

A biophysical phenomenon or process can be described as global if it is either of global occurrence, namely occurring or expected to operate in all or most of the global land, or if it is prevalent only at the local scale, but its effects or outcomes are evident or are expected to have effect at the global scale. Whether land degradation complies with the occurrence criterion, the mammoth project of Global Assessment of Land Degradation (GLASOD) whose results became available in 1990 (GLASOD 1990) could not provide a clear answer. One result is that more than half of global land is degraded, i.e. between 61-65%, and another is that only 15% was degraded in the late 80s of the 20th century. It is the difference in the spatial scale used for assessment that generates these two largely diverging values: the low values represent summation of the land actually degraded in each area unit, whereas the high values are derived from summing up the total area of each map unit within which degradation was detected, irrespective of whether only part or the whole unit's area was degraded. Surely the 15% value stands for tangible degradation, whereas the 65% figure is overly inflated, and the question is what purpose this inflation served.

1.1. Global land degradation and desertification

The launching of the GLASOD project was motivated by the 1968-1974 Sahel drought succeeded by the even more severe one of 1983-1985. The human plight during the latter experienced by around one hundred million people, of which one million starved to death, was then attributed to land degradation brought about by the combination of drought and the overexploitation of land resources by the burgeoning Sahel population. The term “desertification” coined in the early 1930s for describing the “advancement of the Sahara” into North Africa was then revived and applied by the United Nations Environment Programme (UNEP) and later by Agenda 21 to land degradation in the drylands. And, in order to mobilize the international community to “combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa” (United Nations Convention to Combat Desertification) it was necessary to demonstrate, in spite of that full title of the forthcoming UNCCD, that desertification is not only a problem of the Sahel or of Africa in general, but its dimensions are global. GLASOD’s implicit mission was then to highlight this globality of land degradation, with an emphasis on desertification.

1.2. Is desertification global?

The interest in the globality of desertification prompted an extraction of dryland degradation as a subset (41% of the global land) of the GLASOD global land degradation, to be presented in UNEP’s World Atlas of Desertification. Two other assessment projects were launched by smaller teams than that of GLASOD – “Desertification of Arid Lands” (Dregne and Chou, 1992) and “Land-cover – Land-use change – Drylands (LUCC)” (Lepers, 2003). Two sets of value ranges for the spatial extent of global desertification were produced by these three assessments. The first range is that of 4-74% of desertified global land (Table 1, last row). The differences within this very wide range are attributed to differences in mapping scales (as described in the previous section) and depend on whether the huge hyper-arid drylands are included or excluded from the analysis. The second range of values results from attributing the term “desertification” only to the “very severe” degree of land degradation in the drylands, thus implying that the other three degrees of lower severity of degradation used by all three assessments do not really qualify as “desertification”. This set of values yields only 0.1-10% of global lands as already desertified (Table 1, third row from bottom).

Thus, depending on needs, stakeholders have been able to choose any of the values within the range of 0.1-74% for addressing the spatial extent of global desertification, depending on whether they wished to support or reject the notion of desertification’s globality. In practice, however, there has been a gradual shift in this usage between 1993, when negotiations on drafting the UNCCD initiated, and 2006 when this Convention terminated a decade of being in force. Namely, at the beginning of this period the figure mostly used was the alarmist one of 70%, whereas towards the end of this period quoting the 10% figure has become more prevalent (e.g. Millennium Ecosystem Assessment, 2005).

Table 1. Assessments of the status of dryland degradation (desertification). Adapted from Safriel (2007).

Assessment	Desertification of Arid Lands (Dregne, 1983, 1992)								Global Assessment of Soil Degradation (GLASOD) 1991								Land-Cover Land-Use Change - Drylands (LUCC) - 2003			
Sources	Dregne 1983				Dregne and Chou 1992				WAD[1]		WAD[2]		GLASOD database[3]				Lepers 2003, Lepers et al 2005			
Dryland zones assessed[4]	HA A SA DSH				HA A SA DSH				HA A SA DSH		HA A SA DSH		HA A SA DS		HA A SA DSH		HA A SA DSH		HA A SA DSH	
Area assessed (1000 sq.km)	47,063 [5]				51,597 [6]				51,692 [7]		61,473 [8]		51,125 [9]		60,902 [9]		51,692 [7,16]		61,473 [8,16]	
% degraded by categories[10]	"Classes" [5]		Land uses[11]		"Classes" [12]		Land uses[13]		"Degrees" [14]		"Degrees" [15]		"Severity" [9]				"Main areas of degraded land" [16]			
	Slight[17]	52	Irrigate	1	Slight	30	Irrigated	0.8	Light	8	Water	8	Low	15	Low	15				
	Moderate	29	Rainfe	5	Moderate	29	Rainfed	4	Moderat	9	Wind	8	Medium	26	Mediu	23				
	Severe	18	Range	65	Severe	39	Range	65	Strong	3	Chemical	2	High	24	High	22				
	Very severe	**0.2**			Very severe	**2**			Extreme	**0.1**	Physical	**0.6**	Very high	**8**	Very high	**8**	Very severely degraded	**4**	Very severely degraded	**10**
Total degraded (1000 sq.km)	22,543 [18]		32,718		35,922				10,352		11,370		37,588		41,221		1,959		6,147	
% degraded of assessed area[20]	48		70		70				20		19		74		68		4 [19]		10 [19]	

[1]World Atlas of Desertification (WD), Middleton and Thomas, 1997. Values based on tables in the WAD using GLASOD database and a delineation of the drylands from maps of the dryland zones done commissioned by UNEP to the Climatic Research Unit (CRU) of the University of East Anglia (UEA), using their data sets to derive global Aridity Index values. This dryland types data set was downloaded from the MA core database.
[2]Data from Oldeman 1994, based on GLASOD data base and the global aridity zones delineation by the CRU/UEA (see footnote 1).
[3]Used for the 'Severity' category values, which combine "degrees" of degradation with their spatial extent within mapping units (e.g. map 1.11 p.20 in WAD 1997).
[4]Aridity zones: HA – Hyper-arid; A - Arid; SA – Semi-arid; DSH - Dry sub-humid, following UNEP/WAD classification. Grey zones only are covered by the assessment.
[5]Based on Dregne 1983, Table 6.2, p.174.
[6]Based on Dregne and Chou 1992, Table 1.
[7]Based on WAD, Table 1.1 p. 5 and Table 1.4 p. 18.
[8]Based on WAD, Table 1.1 p. 5.
[9]From GLASOD digitized database downloaded from ISRIC website to the Millennium Ecosystem Assessment (MA) "core data" (e.g. Safriel and Adeel 2005, Fig. 22.9 p. 640)
[10]Terminology for each category used by the different assessments is preserved. The bottom category (bolded figures in a highlighted grey cell) are regarded by the authors of the assessments as a practically irreversible state, which by some it means, in the drylands - "desertification"
[11]Based on Dregne 1983 Table 1.3 p.19; these land uses occupy 41,018,000 km^2 of the assessed "used" dryland, of 47,063 km^2
[12]Based on Dregne and Chou 1992 Table 8.
[13]Based on Dregne and Chou 1992 Tables 3,5,7.
[14]Based on WAD Table 1.4 p.18.
[15]Based on Oldeman 1994, Tables 7.1 - 7.4 pp 108-111. Assessing degradation types (water and wind soil erosion, chemical and physical soil deterioration).
[16]From Lepers, 2003. Degradation is the highest degree (of 3-4 degrees in 5 of the data sets used, or values above a high threshold in all other data bases). Note also that only 62% of the drylands (including the hyper-arid) are covered by data accepted by this assessment, what makes the total assessed global area smaller than presented in the row above.
[17]This class also includes non-degraded areas, mostly occurring in the hyper-arid zone.
[18]'Moderate' to 'very severe', i.e. 'slight' excluded.
[19]Note that this percentage is close to the GLASOD 'high severity' degradation, since in both assessments the mapping scale results in an exaggeration - mapping units defined as degraded are only degraded in part of their area.
[20]These values, though each is a percentage of a different definition of the term 'dryland', are often used to denote 'dryland degradation', or 'desertification'.

2. The Shortcomings of 'Desertification'

Given the high between- and within-study variation in the extent of desertification presented by the different studies, it is evident that when using the spatial extent criterion, the globality of desertification cannot be defended. The root cause of this variation is not just the use of different mapping scales and the choice of different degradation severity criteria by these researchers, but the weakness of the definition of the process they set out to assess. This definition of desertification, spelled out by Article 1 of the UNCCD, can be described as cumbersome, imprecise and loose, leading to such qualifications as "an open concept" (Warren and Olson, 2003). This is exemplified by a 2004 paper published in the journal *Conservation Biology* entitled "Effects of Desertification Caused by *Lithophaga lithophaga* (Mollusca) Fishery on Littoral Fish Assemblages along Rocky Coasts of south-eastern Italy", dealing with the effects of shellfish fisheries on coastal algae. To quote: "The major consequence" of this practice "…is the removal of the biological cover (macroalgae, zoobenthos), which ranges from bare patches to complete desertification", which suggests that "…pressing topics for future research ..." is the "…effects of desertification on fish…" (Paolo et al., 2004). Furthermore, "desertification" was explicitly implicated in being "used as a deliberate strategy to attract attention of funding; 'spin' is another word…". This is exemplified by a proportion of non-dryland developing countries in the UNCCD membership increasing from 20% in 1996 out of 56 countries ratifying the Convention by that year, to 36% in 2003, when the UNCCD had 190 contracting parties. To comply with their commitment to the Convention, many of the 93 dryland ("affected") developing country parties prepared and submitted for donors' support

“National Action Programmes to Combat Desertification" (NAPs). This procedure was also practiced by many of the current 69 non-dryland country parties, in spite of the fact that in having no drylands, by definition these countries can not be affected by desertification, yet they claim to combat it… To conclude, not only the free usage of the term "desertification" contributed to the extreme disparity in values of land degradation in 41% of the global land, but both the loose definition and the inability to assess the extent of the phenomenon might have hampered addressing it effectively.

3. Is Land Degradation Global? The Global Effect Criterion

Faced with the shortcomings of the definition of desertification and with the inability to determine the spatial extent of its occurrence at the global scale, land degradation, though limited only to the drylands and possibly so far affecting (or severely affecting) only a very small proportion of them - most likely 10% (Millennium Ecosystem Assessment, 2005) or even less (see above), can have a “transboundary” effect spanning large parts of the globe, even way away from the drylands themselves. For example, desertification has been implicated for generating dust storms that travel long distances within the drylands, and not only cross the dryland boundaries but are even transoceanic. However, it is estimated that only less than 10% of the global dust storms are due to desertification, and moreover, there might be some tangible benefits to the ecosystems in which this transboundary dryland dust is deposited (Safriel, 2006a). Thus, the physical phenomenon, that of trans-dryland dust storms, do not provide support to the notion of desertification's globality.

But desertification might have social implications of a strong transboundary effect. For example, the migration from developing to industrial countries, such as that out of Africa or of the Near East to Europe, is often attributed to desertification. However, no statistics are available either to demonstrate that the root cause of this migration is desertification, or that a high proportion of these migrants are of a dryland descent. Yet, one can confidently link three relevant observations: all these migrants are from developing countries; most drylands are in developing countries; and, the migration of most migrants is driven by poverty. Therefore, it is safe to assume that a very large proportion of global migration is driven by poverty in the drylands. Thus, it is living in the drylands, and not necessarily desertification, that generates poverty as well as drives migration. In other words, in a globalized world, local poverty, i.e. poverty in dryland areas, has global effects and should be of global concern.

4. The Expressions and Sources of Dryland Poverty

There is no hard evidence of how much poverty there is in drylands. This is because like desertification, poverty is loosely defined, and its statistics are usually available at the country scale in which drylands are aggregated with non-drylands. An attempt of the Millennium Ecosystem Assessment (MA) to compare the Gross Domestic Product (GDP) of people aggregated by ecosystems rather than by countries revealed that, at least in Asia, the GDP per capita is lower in drylands than in the other five ecosystems, which, when combined, cover the Asian land surface (Fig. 1). It is thus likely that dryland peoples are on average less affluent than people of other ecosystems, but the fact that drylands also exhibit the highest infant mortality rate compared to that of other ecosystems (Fig. 1) may point to a severe relative disadvantage of dryland livelihoods.

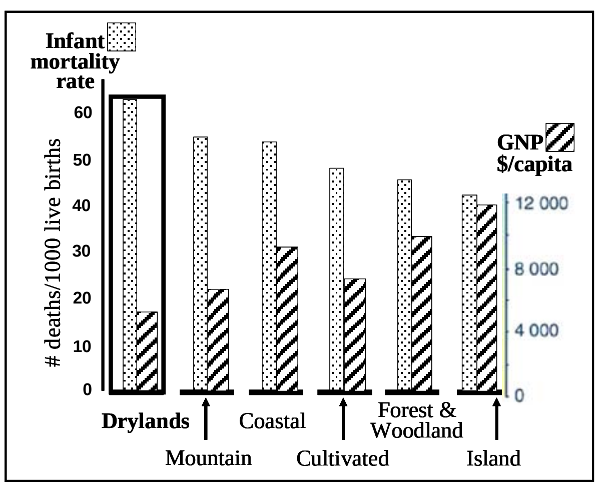

Figure 1. Poverty indicators in Asia (after Millennium Ecosystem Assessment, 2005).

Another product of the MA is an assessment of the average net primary production of the global ecosystems, and not surprisingly, it shows that drylands have the lowest value in the provision of this essential ecosystem service (Fig. 2). But what is surprising is the MA finding that the human population growth rate (during the last decade of the 20th century) was highest in the drylands (Fig. 2). Thus, this combination of the highest growth rate of the dryland population attempting to generate livelihood from the globally lowest natural, inherent land productivity can in itself breed poverty, with no need to invoke desertification. By the same token, this combination of high population growth and low land productivity can pose desertification risk, yet poverty can emerge even prior to the materialization of this risk.

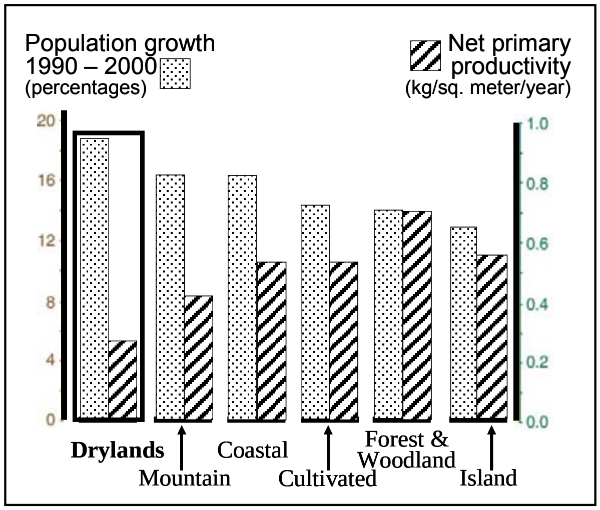

Figure 2. Land productivity and human population growth in ecosystems covering most of the global land area (polar ecosystems excluded). Source: Safriel, 2007.

To conclude, though migration has recently become a problem of a global scale and its link to poverty is undisputable, and though poverty is tightly linked to dryland livelihoods, hard data for attributing either migration and/or poverty to desertification is not available. Therefore, desertification fails to comply with the transboundary impact criterion of globality. Yet, another source of a transboundary impact of desertification may exist, one which is linked to the phenomenon of human-induced global climate change.

5. Climate Change and Desertification

One of the local impacts of human-induced global climate change is the projected increased evaporation (and transpiration) and reduced precipitation in the drylands (Meehl and Stocker, 2007). These combined would lead to reduced soil moisture and hence water availability for primary productivity. This reduced productivity in the drylands is likely to exacerbate global warming, in different ways (Fig. 3). First, the global carbon sink, i.e. the function of photosynthesis in fixing atmospheric carbon, will be impaired by the reduced soil moisture, which is in drylands the limiting resource of productivity. This would also reduce the global carbon reserve in two tracks. First, the overall plant biomass (including the above- and below-ground vegetation cover) which is the live carbon reserve will be reduced. Also, the transport of carbon from the live parts of plants to the soil, in the form of litter to be transformed to soil organic matter, will be reduced. Thus, altogether the rate of increase of the global carbon reserve will be slowed down. In addition to this, the reduction of vegetation cover due to reduced water availability would lead to intensified soil erosion, which in drylands is one of the major expressions of desertification. Most significantly in this context, the carbon stored in drylands soils is likely to be oxidized once soil is eroded and its stored organic compounds exposed to air and water.

Soil erosion thus results in overall increased carbon dioxide emissions from the drylands to the global atmosphere, which intensifies the global warming that further impacts drylands. Similarly, since soil organic matter increases the soil's water holding capacity, the overall loss of soil organic carbon caused by desertification (whether human-induced or climate change-induced or both), causes further reduction of soil moisture in the drylands. To conclude, two positive feedback loops are involved in the desertification-climate change linkages, whereby these two processes intensify their mutual exacerbation (Fig. 3).

The currently evident desertification expressed in soil erosion, irrespective of whether its spatial extent is small or large, or whether or not it has been exacerbated by climate change, already contributed and is contributing to an increase in carbon emissions to the global atmosphere. Similarly, the processes that have led and are leading to soil erosion in the drylands, i.e., reducing vegetation cover due to overgrazing and to transformation of rangelands to croplands, already reduced and are further reducing the sink function as well as the carbon reserve stored in the drylands, which also contributes to global warming and climate change. However, the proportional contribution of drylands to the increased atmospheric concentration of atmospheric carbon dioxide has so far been small (only about 4% of the total global emissions from all sources combined originate in the drylands) (Millennium Ecosystem Assessment, 2005). Yet this amount is expected to increase (Safriel and Adeel, 2005), depending on global emissions and desertification trends. To conclude, whether resulting from the misuse of land by drylands people, or being exacerbated by global climate change, desertification contributes or has the potential to contribute to global climate change. Although the magnitude of the projected contribution is not yet quantified, it attributes a degree of globality to land degradation in the drylands.

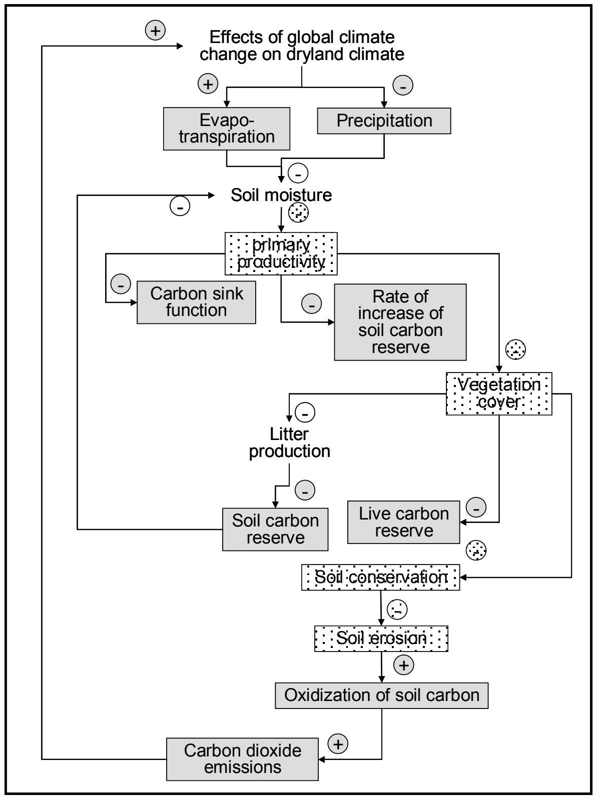

Figure 3. Effects of global climate change on desertification (dotted rectangles) and effects of desertification on global climate change (grey rectangles). Arrows with minus signs stand for reduced rates or quantities, and arrows with plus signs stand for an increase in effect.

6. Global Climate Change and Drylands Opportunities

The UNCCD process has promoted ideas, tools and instruments for addressing, or "combating" desertification, which mostly addresses avoiding degradation of land while aspiring to promote further development of the drylands, mostly through increasing land productivity. Similarly, through the United Nations Framework Convention on Climate Change (UNFCCC) mechanisms to both mitigate climate change and adapt to its effects have been proposed, and these are also expected to assist in avoiding the exacerbation of desertification and in promoting increased drylands' biological productivity. However, by 2050 the projected persistent growth of the global human population is expected to make humanity short of 4.5 million km^2 of good cultivable land for providing its nutritional needs (Safriel and Adeel, 2008). This would bring added pressure on agriculturally marginal lands, those of naturally low productivity, mainly found in the drylands. The mounting pressure may prove to be beyond the ability of handling, by all measures, "combating desertification" through increasing land productivity. Thus, even if the current extent of desertification is relatively small and means to avoid it while promoting land productivity improves, an eventual widespread desertification and poverty are inevitable, since land productivity is not limitless. It is therefore timely to explore alternative livelihoods in the rural dryland areas, ones that reduce pressure on land resources yet promote the human well-being of the growing population. And in this context, paradoxically, the projections of global climate change offer some bright prospects for drylands people. These prospects of alternative livelihoods are in sharp contrast to those of the ominous vicious circle of the desertification-climate change nexus portrayed in Figure 3, in which all dryland livelihoods are based on land productivity.

7. Carbon Sequestration as a Dryland Alternative Livelihood

Following the publication of the Fourth Intergovernmental Panel on Climate Change (IPCC) Assessment Report in late 2007, the recognition of the prevalence of the climate change syndrome and the awareness of the need to mitigate it and to adapt to its impacts have become widespread, and the quest for solution is expected to intensify. In this context, it may be instructive to draw attention to the inherent drylands' potential and relative advantage over other areas in promoting the mitigation of climate change at the global scale. The first relevant attribute of drylands is in their potential for mitigation through increasing carbon sinks and reserves. Arresting desertification, restoring the sink function of degraded drylands and even promoting the sink function of the vast non-degraded drylands, for example, through dryland afforestation (Safriel, 2004; Safriel, 2006b; ICARDA, 2007) can have a significant contribution to the global mitigation effort. More importantly to drylands people, promoting the drylands sink can generate a new source of income, under the Clean Development Mechanism (CDM), and other carbon trading mechanisms under the outgoing Kyoto Protocol and the currently negotiated new international legal instruments under the UNFCCC. Note that the sink function is carried out by plants; hence, its promotion as a drylands livelihood still depends on biological productivity. But drylands afforestation for carbon sequestration is not as exploitative and degrading as the traditional pastoral and farming dryland livelihoods.

8. Drylands' Renewable Energy Options

The second relevant attribute of drylands is their potential for mitigation by reducing global carbon emissions, and this is through the development of alternative, renewable energy sources. In two tracks of renewable energy development drylands not only have high potential, but also a relatively competitive advantage. The first depends on biological productivity, but one that is totally detached from the land and its soil – biofuel produced from aquaculture of unicellular algae. Desert aquaculture is an emerging drylands livelihood, mostly practiced in drylands of industrial countries (Safriel and Adeel, 2005), but also in developing ones (Adeel and Safriel, 2008). It has been demonstrated that the water demand of agricultural crops cultivated in drylands is higher than that of aquaculture products cultivated in drylands (Safriel and Adeel, 2005). Furthermore, not only is dryland aquaculture economic on land use and does not degrade it, but also the economic returns of aquaculture products may be higher when cultivated in drylands than when cultivated in non-drylands. Finally, though most aquatic organism cultivated in drylands are fish and crustaceans, algae of high commercial value are cultivated too (Warren, 2006). Much research and development is still required for production of biofuels based on unicellular algae, but this avenue should not be neglected.

Most prospects are of course in harnessing the highly abundant, year-round solar radiation available in drylands as a source of renewable energy. It has been calculated that 4% of the global desert area can provide the whole current global annual energy demand (Safriel, 2004), or that an area of 320 km^2 of the Sahara Desert can provide all the annual energy demand of Europe (Warren, 2006), provided that such areas are supported with installations already equipped with available technologies. Here too, research and development is still required for improving means of electricity storage and transportation, compatible with conditions prevailing in dryland environments. Moreover, research is needed into the cultural, social, economic and political issues that need to be resolved to guarantee that dryland rural communities receive their fair share of the accrued income, as well as that they are rewarded for their contribution to the mitigation of global climate change.

9. Traditional vs. Alternative Dryland Livelihoods

The climate change-induced and other alternative dryland livelihoods are not equally implementable and beneficial in all drylands. It is necessary to recognize that 'drylands' is not a uniform ecosystem but represent a series of ecosystems positioned along an aridity gradient. The position of an ecosystem along this gradient determines the relative advantage of alternative vs. traditional livelihood and the appropriate mix of the two to be practiced. Paradoxically, the economic advantage and relative benefit of alternative livelihoods increases with increased aridity. For example, both aquaculture and solar energy production are more advantageous in desert drylands than in non-desert drylands, due to lower competition on water and land resources in the former than in the latter. Drylands afforestation as a carbon sequestration project, on the other hand, is more advantageous at the boundary between desert and non-desert drylands rather than in the drylands at the two extreme ends of the aridity gradient (i.e. in the hyper-arid and the dry sub-humid drylands). It can therefore be recommended that the climate change-induced alternative livelihoods will gradually replace livelihoods depending on exploitative land productivity as aridity increases. Thus, most efforts in sustainably improving land productivity should prevail in the dry sub-humid drylands, but should cease to be practiced in hyper-arid drylands. Solar energy development, on the other hand, is best practiced in the latter, but also arid areas where aquaculture can flourish. In arid areas, on the other hand, both traditional and alternative livelihoods can coexist (Fig. 4). Furthermore, the alternative ones can provide a backup to the traditional ones. This is because of dependence on biological productivity whereby the latter are highly vulnerable to the climatic and market variations, to which the alternative ones are more resistant.

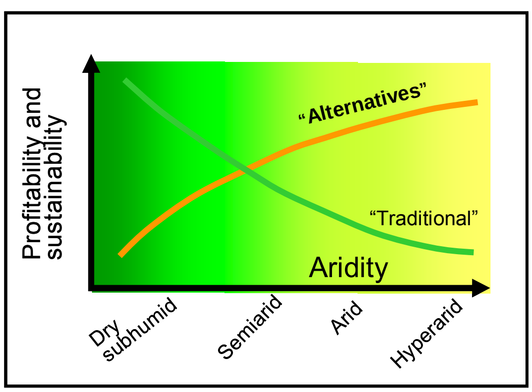

Figure 4. Positioning the mix of traditional and alternative dryland livelihoods along the drylands' aridity gradient.

Conclusion

Regarding the state of current global land degradation, its spatial extent is not yet determined. It has a potential, which might already be partly materialized, to breed poverty in drylands, mainly due to the combination of low natural productivity and high human population growth. The risk of land degradation, especially in drylands, is high and increasing. Both expressions of global change, globalization and climate change, constitute risks and prospects, or pose challenges and opportunities to drylands' inhabitants. As for globalization, the potential linkages between land degradation, poverty and migration are of mounting concern, and the globally dwindling amounts of good cultivable land while population growth continues is likely to generate severe degradation in drylands as well as in other marginal lands. As for climate change, it exacerbates desertification, and may also be exacerbated by desertification. But the need to mitigate it creates new economic opportunities in drylands. Their natural attributes make them highly suitable for developing livelihoods based on solar energy production as well as biofuels based on the culture of aquatic microalgae. Also, mobilizing land productivity for carbon sequestration may become a viable economic option for drylands people. Nevertheless, the prescribed mix of traditional and alternative dryland livelihoods should be tailored to the degree of aridity which characterizes each of the different dryland ecosystems.

References

Adeel, Z. and U. Safriel, 2008. "Achieving Sustainability by Introducing Alternative Livelihoods" in *Sustainability Science* 3(1),125-133.

Dregne, H.E. 1983. *Desertification of Arid Lands*. London, Harwood Academic Publishers.

Dregne, H.E. and Chou, N.1992. "Global Desertification and Costs" in H.E. Dregne (ed.), *Degradation and Restoration of Arid Lands*. Texas Tech University, Lubbock, pp. 249-282.

GLASOD, 1990. *Global Assessment of Soil Degradation*. International Soil Reference and Information Centre, Wageningen, Netherlands, and United Nations Environment Programme, Nairobi, Kenya. Available at: http://lime.isric.nl/index.cfm?contentid=158.

ICARDA, 2007. *Building Bridges of Confidence. Final Report of the Middle East and North Africa Regional Initiative for Dryland Management*. FAO, Rome.

Lepers, E. 2003. "Synthesis of the Main Areas of Land-cover and Land-use Change" in *Millennium Ecosystem Assessment, Final Report*. Available at: http;//www.geo.ucl.ac.be/LUCC/lucc.html.

Meehl, G.A. and T.F. Stocker, 2007. "Global Climate Projections" in *IPCC Fourth Assessment Report, Working Group I Report "The Physical Science Basis"*. Cambridge University Press, Cambridge, England, pp. 748-845.

Middleton, N. and D. Thomas, 1997. *World Atlas of Desertification*. Arnold, London.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Desertification Synthesis*. World Resources Institute, Washington, D.C.

Oldeman, L.R. 1994. "The Global Extent of Soil Degradation" in (eds.) D.J. Greenland and I. Szabolcs, *Soil Resilience and Sustainable Land Use*. CAB International, Wallingford, pp. 99-118.

Paolo, G., S. Fraschetti, A. Terlizzi, and F. Boero, 2004. "Effects of Desertification Caused by *Lithophaga lithophaga* (Mollusca) Fishery on Littoral Fish Assemblages along Rocky Coasts of south-eastern Italy" in *Conservation Biology* 18(5), 1417-1423.

Safriel U.N., 2004. "Alternative Livelihoods in Drylands" in (eds.) Adeel, Z., D. Clancy and A. Dubreuil, *Challenges for Drylands in the New Millennium. A Cross-cutting Approach for Assessment*. UNU-INWEH, Hamilton, Canada, pp. 33–53.

Safriel, U., 2006a. "Deserts and the Planet – Linkages between Deserts and Non-Deserts" in (ed.) E. Ezcurra, *Global Deserts Outlook*. UNEP, Nairobi, pp. 49-72.

Safriel, U.N., 2006b. "Dryland Development, Desertification and Security in the Mediterranean" in (eds.) W.G. Kepner, J.L. Rubio, D.A. Mouat, and F. Pedrazzini, *Desertification in the Mediterranean Region. A Security Issue*. NATO Security through Science Series, Volume 3, Springer Publishers, Germany, pp. 227-250.

Safriel, U. N., 2007. "The Assessment of Global Trends in Land Degradation" in (eds.) M.V.K. Sivakumar and N. Ndiaugui, *Climate and Land Degradation.* Springer, Berlin, pp. 1-38.

Safriel, U. and Z. Adeel, 2005. "Dryland Systems" in (eds.) R. Hassan, R. Scholes and N. Ash, *Millennium Assessment, Ecosystems and Human Well-being. Volume 1: Current State and Trends*. Island Press, Washington, pp. 623-664.

Safriel, U. and Z. Adeel, 2008. "Development Paths of Drylands – Is Sustainability Achievable?" in *Sustainability Science Journal* 3(1), pp. 117-123.

Warren, A. 2006. "Challenges and Opportunities – Change, Development, and Conservation" in (ed.) E. Ezcurra, *Global Deserts Outlook*. UNEP, Nairobi, pp. 89-109.

Warren, A. and L. Olsson, 2003. "Desertification: Loss of Credibility Despite the Evidence" in *Annals of Arid Zone* 42(3-4), pp. 271-87.

The Global, Social and Ethical Context of Sustainable Land Management

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Introduction

Land degradation is a global problem. There is a growing recognition that combating land degradation through sustainable land management is not merely a matter of getting the technology right – it is also imperative that we get the ethics, incentives and policies right

While land degradation is being effectively combated in some parts of the world, this by no means is universal, and along with the prospects of negative impacts from climate change, the situation is expected to worsen in the future. The Millennium Development Goals (MDGs) – the first worldwide attempt to chart a common course with clear deliverables for sustainable development – cannot be achieved if land degradation trends continue. The majority of developing countries with serious land degradation problems are not achieving their goals under MDG 1 (reducing poverty by half by 2015). According to recent estimates, while many regions have been able to reduce the poverty rate, it remains a major problem in sub-Saharan Africa, which is also a region greatly affected by land degradation.

Poor land management by past and present generations has resulted in loss of ecosystem services on a grand scale. The Millennium Ecosystem Assessment (MA) (2005) has helped us to use global statistics more realistically, though the rate of global land degradation is still unclear. But both the MA and the speakers at this Forum have reaffirmed that land degradation occurs in every country around the world, and therefore is of global concern.

1. Socio-economic Conditions

Population increase, a North-South divide in terms of income, energy use and consumerism, and globalization and migration are factors that affect equity and equal access to a minimum standard of human well-being, and affect sustainable land management efforts.

1.1. Population increase and its consequences for the land

The population of the world is increasing; currently, it stands at 6.68 billion people, and is projected to grow to 8 billion people by 2020. The human footprint continues to have a huge impact on natural resources. But we often forget to look beyond the rural landscape. Cities, roads and airports now cover 2% of land area, or 2.6 million km^2. While the global rate of urbanization is now at 48% and increasing, this is no panacea for our rural landscapes: it merely increases the pressure on rural areas to provide more consumerables, such as wood for furniture and paper, or food for feeding the hungry in the cities.

With this increasing population, the competition for land is growing. Croplands and pastures now cover about 40% of the world‘s land area. The Millennium Ecosystem Assessment reported that expansion of cropland into forests and pastures is the single most contributing factor to land degradation. But these croplands themselves are vulnerable to degradation, especially with increasing fragmentation of holdings, declining nutrient load and water holding capacity. The current land degradation rate, if not reversed, will lead to 50% loss in crop yields in the next 40 years, seriously undermining food security, and fuelling a vicious cycle of more cropland expansion into natural areas and competition for land. If these trends continue, we will soon be talking about “nutrient credits” in addition to the water and carbon credits of today.

1.2. Biofuels: a blessing or a curse?

The current demand for biofuels, coming primarily from the commercial transport sector, has already created serious environmental damage where it has been unsustainably produced. While in some countries, such as Brazil, fuel from sugar cane has been sustainably produced in the past decades, the current high demand is raising the spectre of massive land conversion in the *cerrado* (adding to the land conversions for soya beans), in tropical coasts and peatlands through palm plantations, and large-scale conversion of rangelands and other drylands to jatropha. Biofuels can have positive or negative effects on food security, soil and water quality, rural employment and global climate change. This depends on many factors, such as: i) ecological conditions and environmental policies at the local and national levels (protection of virgin lands, certification, etc.); and ii) land ownership, access to finance, and involvement of farmers in the production, processing, use and trade of biofuels.

1.3. The widening income gap

The gap in per capita income between the richest and the poorest countries has widened. While the income gap was 30:1 in 1960, in 2000 it had increased to 80:1. According to the World Bank (WB), 950 million people live under US$ 1/day, which is classified as the threshold for extreme poverty (this figure is equivalent to 17.7% of the developing world). When the differences in the cost of living are taken into account, a WB study shows that if a family of three in India, living on US$ 1/day, were to consume at international standards, then their cost of living in India would be US$ 120/day. Globally, 20% of

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[1]Currently with the United Nations Environment Programme.

the world's people in the highest-income countries account for 86% of total private consumption expenditures – the poorest 20% only accounting for a minuscule 1.3% (UNDP Human Development Report, 1998). Specifically:

- the world's richest fifth consume 45% of all meat and fish, while the world's poorest fifth consume only 5%;
- the world's richest fifth consume 58% of total energy, while the world's poorest fifth consume less than 4% of total energy; and
- the world's richest fifth consume 84% of all paper, while the world's poorest fifth consume 1.1% of all paper.

Excluding South Africa, whose economy and power consumption dwarf other nations', Africa's remaining 700 million citizens have access to roughly as much electricity as do the 38 million citizens of Poland. Much of this electricity goes to industry: a single aluminum smelter near Mozambique's capital, Maputo, gobbles four times as much power as the rest of Mozambique, and fewer than one in four sub-Saharan Africans are hooked up to national electricity grids.

1.4. Environmental migration

Extreme poverty and increasing income differentials, combined with environmental degradation in both rural and urban areas, is fuelling the highest rates of environmentally induced-migration ever seen. It is not easy to arrive at definitive estimates of people that have been displaced due to "slow" environmental factors (as opposed to environmental disasters), as the interaction between the environment, other push-pull factors and migration makes this a complex process. Global and regional statistics on environmental migrants is lacking and largely anecdotal. For example, in 1994, the Almeria Statement indicated that 135 million people could be at risk of being displaced as a consequence of severe desertification. Oxford University has used the figure of 150 million by 2050, estimating the number of people displaced by climate change in China alone at 30 million (Lambert, 2002) More recently, Christian Aid (Christian Aid report, 2007) has brought attention by estimating that 1 billion people will be displaced globally by 2050 due to environmental degradation. Even the smallest of these estimates exceeds the number of refugees displaced by war.

The main question is: with such massive mobility, how can the ethic of land care remain internalized, practiced, and protected? It is recognized that some mobility is inevitable, and even a necessity (e.g. urbanization, labour mobility and remittances, movement to adapt to climate change, reducing human footprint on ecologically sensitive areas, etc.). However, forced migration, and especially that forced by environmental degradation, can displace people off the land, reduce their incentives to take care of the land, and increase incentives to exploit ecosystem services for short-term gain.

As Daily and Walker said, with the increase in globalization and multi-lateral corporations, the power of governments to influence the management of natural resources has diminished (Daily and Walker, 2000). In many cases, it has been reduced to a role of managing conflicts between corporate and business interests and local traditions. At the same time, there is a growing movement for localization, manifested through increasing decentralization of government decision-making, the Slow Food movement and other "local is good" advocates, and scientific recognition of the value and power of traditional systems of natural resource management. All of these forces affect decisions taken on land use and land care, but very rarely do they work with each other.

2. Enabling Environment, Policies and Markets

Weakening environmental governance and land tenure insecurity are major impediments to sustainable land management. Relatively limited public funding for sustainable development has fuelled a growing desire for harnessing the power of markets. And yet, the markets themselves have never been good at ensuring equitable distribution or protecting the rights of the poor.

2.1. Linking markets with sustainability

According to Transparency International, of the 163 countries they surveyed in 2005, only 12 have significantly improved their overall corruption rating since 2000. Corruption surrounding the extraction of natural resources, particularly forest resources, has brought local environmental governance to its knees. Corruption in the forestry sector is widespread in many countries due to: strong international demand for consumer products; weak environmental ministries that do not have enough strength or budget to adequately control forest industry and production; powerful economic groups that benefit from illegal logging; and strict legislation (permit procedures, field level monitoring, enforcement), causing high costs for producers who need to access the market and facilitate government documentation (Brown & Wells, 2004). There is a need to reform the regulatory framework for the industry and reduce transaction costs while targeting institutional corruption through strengthening of land rights, simplification of administrative procedures, access to information and greater transparency, awareness in consumer markets, and the promotion of sustainable forest management that will be more prone to exclude free riders from the market place. The European Union's decision to move towards 100% purchase of certified timber by 2010 is a major step forward that should be emulated worldwide.

2.2. The dependence on land

Land is a key component in today's interconnected poverty and environmental challenges. It is the primary means by which many in the world earn a living, invest, accumulate, and transfer wealth between generations. We now know that secure tenure and secure access to natural resources allow rural communities to invest in the future, and organize and gain strength in their negotiations during contractual agreements, be it with the government or the private sector. But land is also at the source of much political volatility, as competition in access to land and resources has often led to tensions locally, regionally or internationally. The unstable peace situation in Côte d'Ivoire, for example, is a consequence of a politically motivated eviction of rural workers of foreign origin from lands they had been using for generations. In Sudan, a history of successive conflicts erupting in rural areas in the wake of droughts and famine pitted pastoralist herders against sedentary farmers. In the Sudanese government's absence of reaction and the lack of systems to handle disputes, the population armed itself, which initiated decades of civil war (Flint and de Waals, 2005).

2.3. Funding for environmental services

Public funding for development has only recently seen a modest upward trend. Official Development Assistance (ODA) from the Organisation for Economic Co-Operation and Development's (OECD) Development Assistance Committee (DAC) to developing countries rose to a record high of US$ 106 billion in 2005 (OECD DAC, 2005). This represents 0.33% of DAC's combined Gross National Income (GNI), not quite as high as the 0.7% target established by the UN General Assembly, and still about US$ 20-50 billion short of the ODA levels needed just to meet the MDGs. The share of ODA's GNI allocated to environmental issues, such as energy access and water, has actually dropped. Estimates are that only about US$ 2-6 billion will be available annually from 2010 onwards for environmental issues (including sustainable land management). Other sources of finance need to be explored to address pressing environmental priorities.

Payment for environmental services (PES) schemes in various forms are being developed. Though the greatest potential in PES systems is in the fisheries sector, the expected amount from cap and trade markets, such as carbon finance, are estimated at US$ 14 billion annually post-2012, and this could raise resources several times greater than what is available through ODA, and influence global investment decision-making. However, as can be seen in the deliberations of Working Group 3 of this important Forum, there are several key barriers to the compliance markets that prevent the market from investing in projects that provide benefits to both global warming and sustainable land management, among them: the high upfront costs and perceived risks involved; difficulties of accessing upfront financing; access to information on technical options; proven but not mature technologies; and, the issue of ownership of carbon credits.

The majority of Clean Development Mechanism (CDM) projects, as defined in Article 12 of the Kyoto Protocol, are located in China, Brazil and India, and the current investment in carbon sequestration from Afforestation/Reforestation projects in the CDM is only 0.2% of the market. In the majority of low income developing countries, the greater part of the carbon flux is from the agriculture and land use sectors, not from the industry and energy sectors.

Lal (2001) has estimated that the dryland carbon reserve is being depleted at the rate of 0.23-0.29 billion tonnes carbon per year due to land degradation. If this amount of carbon were to be sequestered through land restoration techniques, at the current market rate of US$ 5 per tonne of CO_2e, it would mean an annual investment return of US$ 4.2 – 5.3 billion per year.

Voluntary markets have seen this potential for carbon sequestration and are now "picking up steam", as the Katoomba Group has assessed (Hamilton et al., 2007). Forestry projects make up 36% of the volume of voluntary markets, or about US$ 32 million per year, with a substantial amount being traded in South America and Africa. However, the prices paid for verified emission reductions (VER) in the voluntary carbon markets can be very volatile (e.g. ranging from US$ 3/tCO_2e, to US$ 45/tCO_2e), and the voluntary markets are affected by the same barriers as the compliance markets when it comes to benefiting poor countries. The current debate on developing a post-2012 Kyoto regime is an important part of the global policy debate, to which the International Forum in Iceland is expected to contribute.

There is a growing trend of treating environmental services (especially regulatory and production services) as marketable commodities through different PES schemes. Biodiversity credits, certification schemes, water credits and carbon credits are already in the mainstream. Some are talking about pollination services (especially with the recent disastrous reduction of the bee population in North America). Such schemes have the potential to mobilize billions of dollars from the private sector for environmental protection. However, some are questioning the ethics of treating such common and global goods as commodities. The key ethical issues that need to be considered are: Who owns the credits? Who benefits from the credits? Can ownership of carbon emission reductions (CER) be separated from ownership of land? Is there a risk that governments will "nationalize" CERs as they have land, water or other natural resources? How do we ensure "fair trade" when it comes to these environmental markets? Will the private sector take advantage of the lack of knowledge of local communities and purchase land at rock bottom prices? Such questions need to be considered before we can move forward in an equitable way.

Conclusion

In conclusion, land stewardship is a time-honoured concept common to all races and ethnic groups. However, the ethical use of land and its resources cannot survive alone on a concept, and indeed, in many places it is already lost. Policies, incentives and mechanisms for sustainability need to support both a "horizontal" equity (the now) and an inter-generational equity (a sustainable future). Horizontal equity requires that we fix problems generating from: inadequate or conflicting land and natural resource tenure/access; poor governance and decision-making; and, population growth and displacement. There are quite a few good practices and successes to draw from. But perhaps our biggest challenge today is how to scale up these good practices for the future, and to ensure access by all to increased well-being and healthy soils and ecosystem services. Ethical policies and sustainable financing (including the ethical use of the carbon markets) are key challenges that we hope to move forward through our dialogues and actions of this Forum.

References

Brown, D. and A. Wells, 2004. *Illegal Logging: Who Gains From Tighter Controls?* ODI, UK.

Christian Aid, 2007. *Human Tide: The Real Migration Crisis*. Available at: http://www.christianaid.org.uk/Images/human_tide3_tcm15-23335.pdf.

Daily, G.C. and B.H. Walker, 2000. “Seeking the Great Transition” in *Nature*, Vol. 403, January 2000, pp. 243-245.

Flint, Julie and Alex de Waals, 2005. *Darfur, a Short History of a Long War*. Zed Books, London.

Hamilton, K., R. Bayon, G. Tuner, D. Higgins, 2007. *State of the Voluntary Carbon Markets 2007: Picking Up Steam*. The Katoomba Group’s Ecosystem Marketplace, Washington, D.C. Available at: http://ecosystemmarketplace.com/documents/acrobat/StateoftheVoluntaryCarbonMarket18July_Final.pdf.

Hassan, R., R. Scholes and N. Ash (eds.), 2005. *Millennium Assessment: Ecosystems and Human Well-being.* Island Press, Washington, D.C.

Lal, R., 2001. “Potential of Desertification Control to Sequester Carbon and Mitigate the Greenhouse Effect” in *Climatic Change*, 51, pp. 35-72.

Lambert, Jean, 2002. *Refugees and The Environment: The Forgotten Element Of Sustainability*. Available at: http://www.jeanlambertmep.org.uk/document_detail.php?id=30.

OECD DAC, 2005. *Development Cooperation Reports*.

UNDP, 1998. *Human Development Report*. Available at: http://hdr.undp.org/en/media/hdr_1998_en_contents.pdf.

Land Degradation/Desertification, Society and Global Climate Change in Latin America

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Introduction

Global climate change and desertification – the land degradation of drylands due to factors including climate variations and human activities – are among the most serious environmental challenges facing the world today. Both processes entail dramatic situations of economic losses, poverty and migration. This paper provides an update on drylands and desertification status in Latin America. We introduce the issues related to climate change and desertification in the Central Andes Region and in some selected Sustainable Land Management and Desertification Combat Experiences. The processes that are affecting the Andes Mountains and the settlements in their areas of influence, likely to be extrapolated to other drylands in the world, can be used to identify good and bad environmental practices and the lessons learnt from previous experiences.

1. The Future Facing a Changing Scenario: Synergies between Desertification and Global Climate Change

According to the latest Intergovernmental Panel on Climate Change (IPCC) report, the mean temperature of the Earth has risen 0.74°C (0.56 - 0.92 °C) since the beginning of the 20th century (IPCC, 2007). Desertification affects the ecological and economic productivity of more than 30% of the world's drylands (6150 M ha), entailing dramatic situations of poverty and migration. Data from the United Nations Environment Programme (UNEP) (1990) show that 6 M ha/year are lost to desertification processes, representing a financial loss of US$ 42 billion/year in the early 1990s. An economic assessment of the impact of climate change, recently presented by Sir Nicholas Stern (2006), estimates that the impact of global warming at the end of the 21st century could cost as much as 20% of the world's gross domestic product (GDP). According to Stern (2006): "All countries will be affected by climate change, but the poorest countries will suffer earliest and most. Deeper international cooperation will be required in many areas, most notably in creating price signals and markets for carbon, spurring technology research, development and deployment, and promoting adaptation, particularly for developing countries".

Spatial and temporal variations of the Palmer Drought Severity Index (PDSI), a good proxy of both surface moisture conditions and streamflows, reveals that the global very dry areas, defined as PDSI <-3.0, have more than doubled since the 1970s, with a large jump in the early 1980s due to an ENSO (El Niño Southern Oscillation)-induced precipitation decrease and a subsequent expansion primarily due to surface warming, while global very wet areas (PDSI>3.0) declined slightly during the 1980s (Dai et al., 2004). Together, global land areas in either very dry or very wet conditions have increased from 20% to 38% since 1972, with surface warming as the primary cause after the mid-1980s. These results provide observational evidence for the increasing risk of droughts as anthropogenic global warming progresses produce both increased temperatures and increased drying (Dai et al., 2004). These general concepts and processes become much more evident at the regional and local level where the effects and synergies are starting to be visible. The challenge is to analyze how society and the economy will prevent and adapt to these changes.

2. The Situation in Latin America

Contrary to the widespread perception of Latin America as the green subcontinent, with rainforests and woodlands from the Caribbean to the southern tip of South America, drylands – affected by different levels of desertification - comprise 25% of the total land area. Data from the year 2000 indicate that these dryland areas are inhabited by 519 million people, which represents 28% of the total population. Thirty-five percent of this population lives in conditions of poverty, and 16% live in extreme poverty. Unlike other continents, such as Africa for instance, Latin America is urban (75% of the population lives in urban areas) and its deserts are, in the most complete sense of the word, uninhabited areas or areas with very low population density, except for points of population concentration in coastal urban areas such as Lima, Peru.

Desertification in Latin America, as elsewhere in the world, is a combination of natural risks – critical in drylands – and the human pressure that overloads and affects the biological and economic productivity of drylands ecosystems. Outstanding among natural phenomena are the effects of sustained and recurrent droughts; dust storms; pronounced climate oscillations in the semi-arid and dry sub-humid areas; El Niño-Southern Oscillation phenomena affecting land uses in coastal and inner areas; and, reduced snow precipitation in the mountains affecting water supply for settlements in the Andes foothills.

These natural risks should be linked to the human pressure derived from the socio-economic and political situation of the countries in the region: massive deforestation of rainforests and woodlands from the tropical Amazonia to the cold rainforests of Patagonia, including the sub-tropical dry woodlands; accelerated loss of biodiversity; overgrazing and decline of productivity in savannas, grasslands and shrublands; growing rural-urban migration, desertion of productive lands and increased levels of rural, urban and sub-urban poverty; salinization/alkalinization and water table logging in irrigated lands; affected quality and quantity of surface and ground water resources; degradation of soils with high agricultural capacity; unplanned extraction of non-renewable resources (mining, oil); quick loss of traditional knowledge and values; non-desired land use changes; accelerated and unplanned urbanization; foreign debts jeopardizing processes of local development and growth; loss of infrastructure (silting of dams, dredging of harbours, destruction of roads and railroads, bridges, etc.); lack of hierarchies in environmental policies at the national level, among them the combat of desertification; strong processes of poverty and migration; soil loss and salinization; misuse of water resources; and, loss of biodiversity. According to UNEP (1990), desertification reaches alarming figures in South American drylands: 305.81 M ha, over a total of 420.67 M ha of agricultural lands, are degraded (72.7%). Grasslands (390.90 M ha) are the most affected: 297.75 M ha (76% of their total area). In rain-fed lands (21.35 M ha), 6.64 M ha are degraded (31%). In irrigated lands (8.42 M ha), 1.42 M ha are degraded (17%). It is estimated that direct measures to combat desertification to recover a total affected area of 8,415,000 ha in the irrigated drylands of South America would amount to a global cost ranging between US$ 2,024,000 and US$ 5,211,000.

There is clear evidence that South America is experiencing unprecedented climate change. For example, a major retreat of ice bodies during the 20th century has been documented along the Andes, from the tropics in Venezuela and Colombia to the southern tip of the continent in the sub-Antarctic domain (Francou et al., 2005; Ramirez et al., 2001; Leiva et al., 1989; Villalba et al., 2005; Masiokas et al., 2007). The observed general glacier retreat in the warming tropical Andes has increased significantly in recent decades (Francou et al., 2005). Small-sized glaciers are particularly vulnerable in warmer climates, with many of them having already disappeared in several parts of the world during the last century. In many localities across the Andes, reduction in glacier area has been associated with negative trends in snow precipitation and in the Andes rivers run-off. Although in recent decades some basins in the tropical Andes have experienced an increase in run-off as a consequence of glacier retreat, in the long term there will be a reduction in water supply as the glaciers shrink beyond critical limits (Jansson et al., 2003). Recent glacier recession has also been documented throughout the Patagonian Andes. Temperature records in north Patagonia show significant warming, which has been concurrent with negative trends in regional precipitation and streamflows. These climatic variations are largely responsible for the widespread glacier recession documented for northern Patagonia. The south Patagonian region has warmed significantly during the 20th century and also experienced a concurrent, widespread glacier mass loss. On the contrary, the increase in the humidity levels of air masses coming from Amazonia and the sub-tropical Atlantic provokes the arrival of major precipitation events during the summer on the plains east of the Andes. In many cases, these incoming wet air masses are associated with more extreme storms, many of them accompanied by severe hail. These contrasting trends between reduced precipitation in the Andes and abundant rainfalls in the plains are consistent with an increase in humidity proceeding from the Atlantic in the sub-tropical region, and with a decrease in the Pacific contribution to approximately 20°S through to the southern extreme of the continent. Taking advantage of the good performance of the General Circulation Models (Labraga and Lopez, 1997; Labraga, 2005) to reproduce the atmosphere's dynamics associated with the seasonal changes in precipitation in South America, it is interesting to examine different simulation results considering possible future changes across the continent. Figures 1 and 2 present the changes in temperature and precipitation for summer (December to February) and winter (June to August) months projected for the period 2080-2099 in comparison to those from 1980-1999 over Central and South America from the MMD-A1B simulations averaged over 21 models (IPCC, 2007).

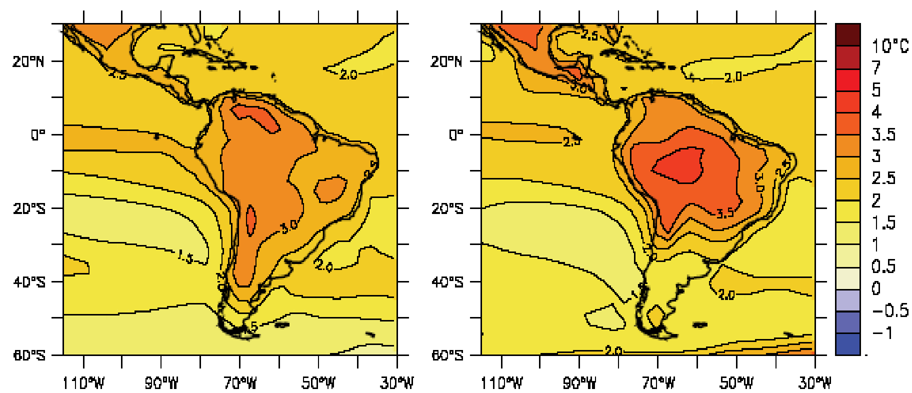

Figure 1. Changes in the summer (December to February, left) and winter (June to August, right) mean surface temperatures (°C) in South America for the interval 2080-2099 in comparison to1980-1999 from the MMD-A1B simulations (from Christensen et al., 2007).

In general, the simulations indicate a similar seasonal increase in temperature in tropical regions, but a larger increase in summer than winter in mid- and high-latitudes in South America (Figure 1). The expected increment of the summer temperatures for the period 2080-2099 is above 3 ºC over the Andes and the plains in the central sector of the continent north of 40ºS. These changes will cause an increment in the regional evapo-transpiration values, alter the proportion of liquid and solid precipitation and the seasonal distribution of the rivers' flow, with an earlier occurrence of peaks of run-off.

The climatic simulations for the period 2080-2099 indicate that the summer precipitation in the subtropical plains will increase between 15-20% (Figure 2). This increment contrasts with a decrease of the same magnitude or even larger in the Central and Patagonia sectors of the Andes Cordillera. There are no expected changes in the winter precipitation in the flat regions, but in the Central Andes of Argentina and Chile there will be a substantial reduction of 20-30% (IPCC 2007; Figure 2). It is important to note that the results of these climatic simulations for the interval 2080-2099 are clearly consistent with the trends recorded in precipitation during the 20th century.

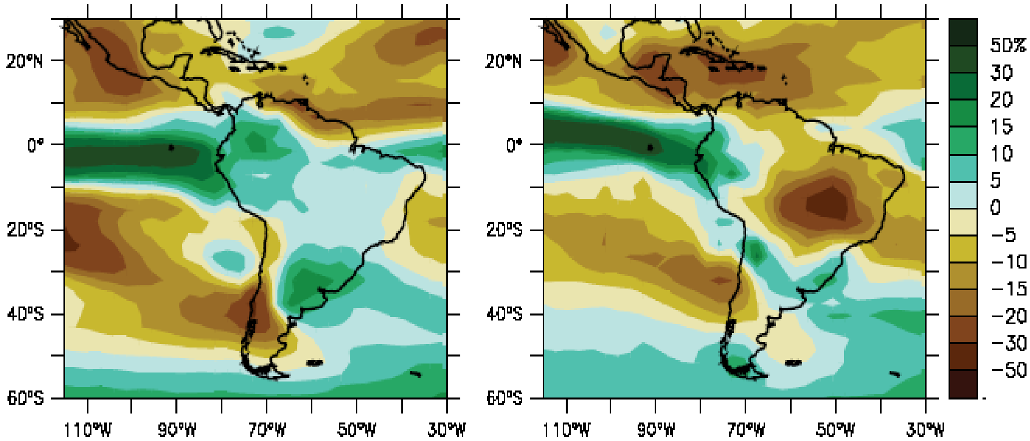

Figure 2. Changes (%) in summer (December to February, left) and winter (June to August, right) precipitation in South America for the interval 2080-2099 in comparison to 1980-1999 from the MMD-A1B simulations (from Christensen et al., 2007).

3. Desertification and Climate Change in the Southern Cone: the Central Andes Region

A transect running at 32ºS, from Valparaíso on the Chilean coast to the Desaguadero river, in Mendoza, Argentina, shows that both sides of the dry Andes face a similar problem: an increasing demand for water resources to sustain urban, agricultural and industrial development (Figure 3). In central Chile, the Metropolitan, V, and VI Regions contain ca. 8.4 million people (55% of Chile's population). About 48% of the annual discharge of the Maipo River (the main water source for Santiago) is withdrawn to meet these needs. Central Chile also accounts for about 45% of the total irrigated area of the country. On the eastern Argentinean side of the central Andes, the rivers serve a population of ca. 2.2 million people in the provinces of San Juan and Mendoza. With less than 200 mm of precipitation per year, agriculture must rely on irrigation. Hydro power plants fed by the Cordilleran rivers generated 62% and 86% of the total domestic energy generation in Mendoza and San Juan, respectively. Special mention is made of the situation of the vast eastern fluvial aeolian plains lying along the Argentinean eastern slope that constitute storage units of water resources, both ground and surface water. In favoured sectors, the beneficial action of rivers has resulted in a Mesopotamian model on the wide alluvial fans. These are the "oases", where the combined offer of water and soils has allowed for the creation of irrigated crop areas and the settlement of cities that articulate their irrigated space of influence in a viticulture agricultural model. These oases and cities, whose main representation is Mendoza - where 97% of the population is concentrated in 3% of the territory – decrease in magnitude from north to south. These are the places where systematized irrigation and joint use of ground and surface water resources are practiced, and where dams for water distribution are built. But these are also the places where water use is more inefficient and land is more highly degraded. And beyond the isolated patches - like green islands – of the oases lies the non irrigated desert, with its immense range of different environments linked by dryness. The desert, which we call "our invisible space" (Montaña et al., 2005), has been neglected by politicians and decision-makers.

These are practically uninhabited drylands – less than half an inhabitant per square kilometre – subjected to accelerated processes of desertification due to abusive use of resources. The irrational management of resources brings about increasingly critical situations: expansion of saline areas and exodus of rural people; decreased carrying capacity of the grazing lands due to their loss of productivity; and the consequent concentration of the rural populations in cities under poorer living conditions.

Our deserts show contrasting activities. On the one hand, subsistence pastoral activities (extensive goat breeding only for meat production) have a strong impact on the fields due to overgrazing. On the other hand, the oil and mining industries extract the richness from the substrate without improving the local territory, many times polluting the water resources. People living there are mainly affected by the lack of water, in both amount and quality. The desert stores water at great depths (in many cases with arsenic), which makes this resource inaccessible to its few inhabitants who have to manage with rudimentary wells and reservoirs. One of the major desertification processes was the logging of the native woodland. At a depth of between 5 and 15 m, the water table feeds the dry open mesquite woodland (*Prosopis spp*.), which deserves particular attention because of its importance to the population. Today, it has practically disappeared. Studies conducted on environmental history show the decline of the woodland in the desert. It was cut down and used to build the viticulture and wine-growing oasis. In a 35-year period, from 1901 to 1935, during the railroad expansion, 992,748 metric tonnes of forestry products were cut down, a total of 198,550 deforested hectares (Abraham & Prieto, 2000). This wood from the desert has been used in the oases as vineyard poles and props. Such studies are important when desert development policies are defined.

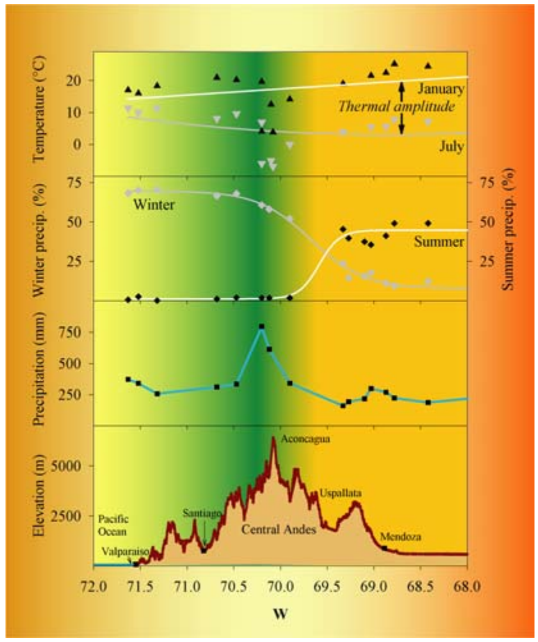

Figure 3. Transect across the Central Andes at approximately 32◦S, showing changes in mean January and July temperatures (upper), in seasonal (summer and winter) precipitation distribution (middle), and in total annual precipitation (lower) associated with topography (bottom). Locations of the meteorological stations are indicated by triangles (▲) in (upper), diamonds (♦) in (middle), and squares (■) in (lower). Meteorological stations in the latitudinal band between 31◦30'S and 32◦30'S have been included in this transect.

Another important desertification process was the use of water in high and medium river watersheds for irrigating the oasis, which resulted in the drying of wetlands in the desert. Several important wetlands (one of them a Ramsar site: "Lagunas de Guanacache") stretched along the margins of the low basin, supporting great biodiversity. The use of the water of rivers for irrigation has stopped their course, and now they are mere sand rivers that no longer carry water, with the logical outcome of wetlands drying. In addition, actions for land recovery and control are scarce and insufficient. The main processes, deforestation, overgrazing, expansion of the agricultural border, urbanization, salinization and water table rise in the oases, land desertion and poverty, continue to bring serious consequences to land degradation.

But, facing the possibility of climate changes at a global scale, the major problem that confronts the region is the uncertainty about climate behaviour in the long/medium term. Scientists warn that 70 years from now the current amount of rain in the sub-tropical plains at middle latitudes of South America might significantly increase, whereas a drastic decrease of snow precipitation will take place at the same latitudes in the Andes Cordillera. Summers will be rainier in the regional plains. In response to global warming and hence, to a more dynamic atmosphere, summer precipitation will be linked to convective storms, with heavy rain and severe hail. Convective storms will affect crops and human settlements, also augmenting the possibility of floods and mudflows in the mountain and piedmont zones. Simultaneously with these changes in the plain, snow precipitation will diminish in the Cordillera during the winter (Table 1). In the present day, the mean Cordilleran precipitation is 250 mm and according to scientists' projection, by the end of the century it will be substantially reduced.

Table 1. Impacts of climate change on ecosystem services across the Central Andes.

ECOSYSTEM COMPONENT	ECOSYSTEM SERVICES	IMPACT OF CLIMATE CHANGE	IMPLICATIONS
Glaciers and snow fields	Provide freshwater to downstream ecosystems	Reduction in annual streamflow	Irrigation in the Central Andes
			Hydropower generation in the Central Andes and North Patagonia
		Timing of snowmelt	Irrigation in the Central Andes
			Hydropower generation in the Central Andes and North Patagonia
	Enhance recreation opportunities & aesthetic values of landscape	Reduction in winter recreational opportunities	Visitor satisfaction
		Loss of landscape icons	Tourism revenues related to water-based recreation across the Andes
		Summer streamflow	Increasing "summer drought" in Northern Patagonia
			Salmon production in Northern Coastal Patagonia

How will the local societies and economies cope with these environmental changes? The water from snowmelt will diminish while summer precipitation will augment, posing deep changes in the management of natural resources. A higher efficiency will have to be achieved in the use of water proceeding from the Cordillera, as it will tend to diminish with time. The unfavourable effects from future increases in summer precipitation will have to be mitigated. These changes could lead to a change in the regional productive activities and, possibly, to a change in the traditional culture of water management in many regions in South America. If we add the generalized desertification processes in practically every ecosystem to this changing climatic scenario, vulnerability increases even more. In a changing world where humid places will be subject to progressive dryness, and the other way around, the map of desertification is likely to change, and so the need will arise for those who already know about the changes that desertification processes entail to transfer their experiences and knowledge to all those unaware of the consequences of land degradation. It is vital to link the experience generated by the United Nations Convention to Combat Desertification (UNCCD) in relation to concrete and practical measures to prevent and combat desertification with the important scientific findings of the other environmental conventions. Thus, the lessons learnt from experiences on sustainable land management become valuable. An instance of a procedure towards an integrated assessment of desertification was developed to launch a case study of Sustainable Land Management and Desertification Combat in the dry central Andes of South America (Abraham et al., 2006).

As a basic conceptual framework, soil was assumed as an environmental issue, as a nexus for the multiple interactions between the natural and social systems that go beyond sector dimensions which are exclusively related to biophysical aspects. This means that soil must be regarded as a *complex problem*. Understanding the environmental problem of soil as an environmental issue requires a theoretical-methodological treatment in transdisciplinary terms that would contain the uncertainty levels typical of complex systems, surpassing simple approaches of reality referred to classificatory structures of thematic variables (land, water, vegetation, demography, etc). How can we deal with the complexity of such an issue? This degree of complexity can only be tackled through the use of Integrated Assessment (IA) and a participatory approach to be able to obtain a Sustainable Land Management Procedure, which means, in practice, linking the generation of knowledge with intervention actions. IA is known (Freitas, 2000) as the intersection between a vertical integration of actors and interests and a horizontal integration of disciplines and sources of knowledge and allows to confront the multiple dimensions of the environment by encompassing natural and social sciences to provide integrated scenarios, likely to simultaneously consider economic, social, ecological and political issues.

4. Sustainable Land Management, Local Level Monitoring, and the Participatory Approach. Case Study within a Case Study?

The Lavalle desert in Mendoza, Argentina is an area with natural, environmental and cultural conditions highly representative of drylands of the Monte desert that stretches for over 614,000 km^2 and other countries in Latin America. This case study has been conceived in the framework of a “research-action” methodology. It includes basic surveys and the obtaining of desertification benchmarks and indicators to the implementation of a “Demonstrative Production and Services Unit” and the “Desert Observatory” to monitor the impact and response of the project (Pastor et al., 2005). The latter is underway at “La Asunción” locality in the core of the Lavalle desert, with the active participation of local actors, mainly the local government and the indigenous communities (Huarpes) in synergy with the scientific/technological sector. While the holistic approach to sustainable land management and desertification prevention is a major improvement compared to the sector approaches of the past, it is a major nightmare for anyone wanting to assess the impact of a sustainable land management programme. In a way, it is on theoretical grounds that we assume that knowledge management, capacity-building, creation of an enabling environmental policy, in addition to on-the-ground interventions, is much better than the traditional technical assistance.

The context of action is the Lavalle desert (10,197 km^2), with a population of 3,213 inhabitants, a disperse population that does not exceed 0.33 inhabitants/km^2. This is the desert where some of the Argentina aridity poles are located (mean annual rainfall is 80 mm at “El Retamo” locality). The main economical activity is a subsistence production system based on goat breeding for meat and manure. The current production system is characterized by high territoriality and individualism, low profitability and negative impact on the ecosystem productivity. Only goat meat is produced, with a survival rate of only 30% of kid goats, because of the winter parturition, when the forage supply is minimal in these desertified lands. Leather is not used, milk is not produced, and the goats are actually only used as a device to produce manure, which is the most looked-for product, and this leads to overstocking, overgrazing and worsening of sanitary conditions. The use of goat livestock at the family scale entails excessive number of goats, extensive grazing techniques, serious problems in land tenure and property, problems in herd sanitation (brucellosis, tuberculosis), and scarce drinking water contaminated with arsenic (HACRE, or Hidroarsenicismo Crónico Regional Enémico).

After more than twenty years of non-stop work on research and transfer in relation to the development of the drylands in Mendoza, the north-western region of Argentina, the Laboratorio de Desertificacion y Ordenamiento Territorial of IADIZA (LaDyOT/IADIZA) began in 2003 to develop and implement the project “Strategies for local development and combat of desertification and poverty in indigenous local communities of the Argentinean Monte desert” through a partnership with the Municipality of the town of Lavalle and the indigenous Huarpe Community of La Asunción, with the financial support of the Argentine-German Technical Cooperation Agency (GTZ), the Federal Investment Council (CFI) and other institutions such as the Inter-American Development Bank (IADB), Land Degradation Assessment in Drylands – Food and Agricultural Organization of the United Nations (LADA-FAO), and the National Secretary of Science and Technology in the framework of the National Action Programme (NAP) for Argentina. This work addresses as its main goals: to combat land degradation and develop a rural/local/sustainable development model that combines the best options for combating desertification among all participants:\; to take the challenge of incorporating deserts in economic and production circuits, according to the motto “living with the desert” rather than combating it; and, to show that the cooperation of scientists, non-governmental and governmental organizations, local governments and communities is possible within a research-action proposal, based on the acknowledgement of the potential existing in the desert, going beyond both compensation- and assistance-based approaches. It is framed within a rural territorial development conception, with the purpose of integrating a rural desert land into dynamic territories in a competitive and sustainable way. We started a process of intervention based on the intensive use of endogenous resources that proposes to generate more sustainable development strategies in rural indigenous communities of the Mendoza desert, to improve the status of the ecosystem through an integrated management of natural and cultural resources, and to promote improvement of the socio-economic conditions of the inhabitants of drylands. Among the objectives, we can highlight the will to have an incidence on current production practices by incorporating conservation concepts and experiences in herd management, preservation and validation of the natural and cultural heritage, reforestation and revegetation of degraded lands, animal and human health, social organization, irrigation efficiency, waste recycling, use of water resources and non-conventional energies, production of organic manure, tourist and cultural services, and fundamentally, obtaining healthy food products.

The work methodology for desertification assessment (Abraham et al., 2006) is based on the design of a participatory procedure where, starting from the identification and prioritization of problems and objectives, we obtain and evaluate desertification indicators and, on the grounds of the shared knowledge of the system and of the desertification processes affecting it, all actors together design the impact hypothesis and the intervention actions. All this will be incorporated into an Integrated System for Desertification Assessment and Monitoring, located *in situ*, at the “Desert Observatory”. Thus, we designed a system based on partnership-building among small producers, where each contributes as many parous goats as possible. These goats are housed at the UPYS (Pilot Unit of Production and Services): a sort of “hotel for goats”, designed to keep them most of the year in order to produce milk, milk by-products, kid goats, sanitation, food supplements, information, basic and applied research and eco-tourism products. The outputs we expect to achieve are: a desert-adapted production system for healthy food (pastures, composting and vermiculture); a laboratory for primary sanitary control of goat herds; a reforestation nursery; an observatory of processes to measure desertification and land recovery; and, an interpretation center for education, transfer and tourism. The numbers are clear and speak for themselves of the direct impact that is being generated in the framework of the recovery of degraded lands and the economy of the production unit “puesto”: only 28 goats incorporated into the UPYS system yield the same profit as the system generated by 200 goats in the current mode of exploitation. Therefore, only 56 goats included in the system are needed to double the family’s monthly income, versus more than 400 in the current mode of work. That is to say that, besides decreasing the pressure of overstocking rate on the fields, their recovery and improvement is being promoted through a reduction of stocking rate and through reforestation and revegetation with native species.

Thus, a highly significant change is being fostered by positioning the producer above the poverty line, a change that is, moreover, easily perceived by the population, and that entails high commitment of adherence to the Project, within a feedback process. This means that, at a local scale, the progress of desertification processes is being reversed and poverty indices are effectively being diminished.

5. Linking Local to National/Regional/Global Levels: Different Scenarios, Depending on the Development Styles Adopted

Integrated Assessment is a good tool at the local level but, rising in scale, the challenge is to relate local progress to progress at national, regional and global scale. In this sense it is essential to discuss and agree on the development model we want for drylands. Among which development models in drylands can we choose?

The inherent fragility of drylands and the high risk they are exposed to under conditions of global change can only be overcome with knowledge, planning, political will and investment. There also needs to be a consensus on the style of development which will be implemented to overcome this fragility and risk. This may change among different scenarios and models that fluctuate between the extreme of those who propose huge transformations in the natural conditions of desert areas – with major investments in capital and infrastructure, best known as “Cadillac” (Ezcurra Ed., 2006), of which the best current exponent is Las Vegas or the megacities of the Gulf, completely separating society from nature - and those in the opposite extreme who want to “leave everything as it is”, not modifying anything in the ecosystem. This last position is supported by groups of extremist “ecologists” who are opposed to any kind of intervention. Midway between these extremes is the view of a sustainable development of drylands, directed towards territorial balance and social equity: the so-called “development in patches” that attempts – based on deep knowledge of the potentials and restrictions of drylands and of the demands and needs of the population – to develop those desert environments showing the least restrictions and the best conditions for settlements and production (corridors, wadis, oases, terraces, sand dune bases) and to restore and preserve the rest of the territory. This model is what we call the Gobabeb model in the Global Deserts Outlook (Ezcurra Ed., 2006), after the homonymous locality in the Namibia desert, where these experiences have been successfully developed. Whichever model we choose, the consequences are quite predictable, and the inherent fragile conditions of degraded lands can only be overcome with: knowledge, planning, political decision, investment, and agreed/equitable development models directed to territorial balance, social equity and sustainable development.

These models can be linked in their effects to the scenarios developed by global climate change experts for worldwide scenarios of climate change associated with the development styles adopted (Figure 4).

Whatever the development model selected, it must be implemented within the frame of a planning and management process, where the generation of knowledge to monitor changes can be given hierarchy and earn importance. This measurement of the status, pressure, impacts and responses, incorporated into an integrated assessment and follow-up system, must be part of a new attitude that values the contributions of science and technology, as a guide for decision-making. If, in addition, this can be achieved through a participative process of knowledge construction, we would be able to advance with more certainty on the road to sustainability, with a more equitable society, in harmony with dry environments.

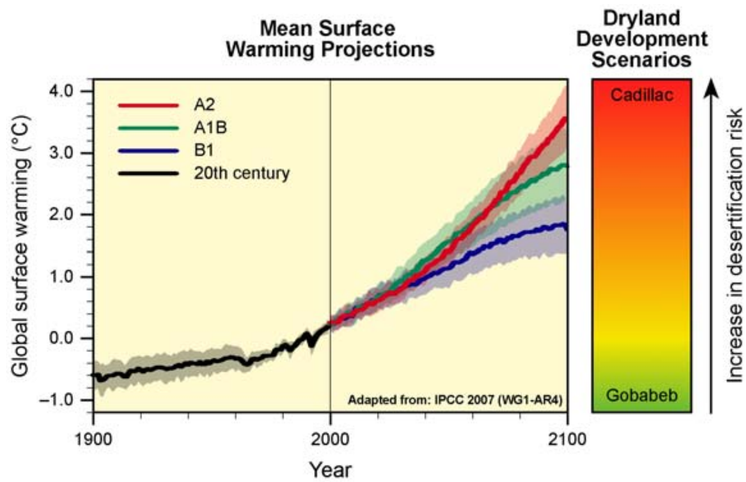

Figure 4. Scenarios of Global Warming and Desertification during the 21st century.

References

Abraham, Elena, Elma Montaña and Laura Torres, 2006. "Desertificación e indicadores: posibilidades de medición integrada en fenómenos complejos" in *Scripta Nova*. Barcelona, Universidad de Barcelona. Available at: www.ub.es/geocrit/sn/sn-148.htm.

Abraham, Elena and M. R. Prieto, 2000. "Viticultura and desertification in Mendoza, Argentine" in *Zentralblatt für Geologie und Paläontologie*, I (7/8), pp. 1063-1078.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr and P. Whetton, 2007. "Regional Climate Projections" in (eds.) Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Dai, A., K.E. Trenberth, and T. Qian, 2004. "A Global Data Set of Palmer Drought Severity Index for 1870-2002: Relationship with Soil Moisture and Effect of Surface Warming" in *Journal of Hydrometeorology*, 5, pp. 1117-1130.

Ezcurra, Ezequiel (ed.), 2006. *Global desert Outlook*. UNEP, Nairobi, 147p.

Francou, B., P. Ribstein, P. Wagnon, E. Ramirez and B. Pouyaud, 2005. "Glaciers of the Tropical Andes: Indicators of the Global Climate Variability" in (eds.) U.M. Huber, H.K.M. Brugmann and M.A. Reasoner, *Global Change and Mountain Regions: A State of Knowledge Overview*. Advances in Global Change Research, 23, Springer, Berlin, pp. 197-204.

Freitas, C. U., 2000. *Explorando modelos e indicadores para o estabelecimento de vegilância dos efeitos na saúde de correntes da poluiçâo atmosférica na cidade de Sâo Paulo*. Sâo Paulo.

IPCC, 2007. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

Jansson, P., R. Hock, and T. Schneider, 2003. "The Concept of Glacier Storage: A Review" in *Journal of Hydrology*, 282, pp. 116-129.

Labraga J.C. and M. López, 1997. "A Comparison of the Climate Response to Increased Carbon Dioxide Simulated by GCM with Mixed-layer and Dynamic Ocean Representations in the Region of South America" in *International Journal of Climatology*, 17, pp. 1635-1650.

Labraga, J. C., 2005. "Simulation Capability of Tropical and Extra-tropical Seasonal Climate Anomalies over South America" in *Climate Dynamics*.

Leiva, J.C., L.E. Lenzano, G.A. Cabrera and J.A. Suarez, 1989. "Variations of the Río Plomo glaciers, Andes Centrales Argentinos" in Oerlemans, J. (ed.), *Glacier Fluctuations and Climatic Change*. Kluwer Academic Publishers, pp. 143-151.

Masiokas, M., R. Villalba, B. Luckman, M. Lascano, S. Delgado, and P. Stepanek, 2007. "20th-Century Glacier Recession and Regional Hydro-climatic Changes in North-western Patagonia" in *Global and Planetary Change*.

Montaña, Elma, Laura Torres, Elena Abraham, Eduardo Torres and Gabriela Pastor, 2005. "Los espacios invisibles. Subordinación, marginalidad y exclusión de los territorios no irrigados en las tierras secas de Mendoza, Argentina" in *Región y Sociedad* 32, pp. 3-32.

Pastor, Gabriela, Elena Abraham y Laura Torres, 2005. "Desarrollo local en el desierto de Lavalle. Estrategia para pequeños productores caprinos (Argentina)" in *Cuadernos de Desarrollo Rural*, 54, pp. 131-150.

Ramirez, E., B. Francou, P. Ribstein, M. Descloitres, R. Guerin, J. Mendoza, R. Gallaire, B. Pouyaud, and E. Jordan, 2001. "Small Glaciers Disappearing in the Tropical Andes: A Case-study in Bolivia – Glaciar Chacaltaya (16°S)" in *Journal of Glaciology*, 47, pp. 187-194.

Stern, N., 2006. *The Stern Review: The Economics of Climate Change*, Cambridge.

UNEP, 1990. *The Assessment of Global Desertification: Status and Methodology*. Ad-hoc Consultation Meeting, Nairobi, 15-17 February 1990, 61 pp.

Villalba, R., M.H. Masiokas, T. Kitzberger and J.A. Boninsegna, 2005. "Bio-geographical Consequences of Recent Climate Changes in the Southern Andes of Argentina" in (eds.) U. Huber and M. Reasoner, *Global Changes and Mountain Regions*. Mountain Research Initiative, Switzerland, pp. 157-168.

Agriculture in African Drylands – A Poverty Trap?

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Introduction: Africa and Change Over the Last 50 Years

Africa is a continent blessed with a unique blend of culturally rich peoples with a myriad of traditional knowledge, innovations and practices that have contributed significantly to natural resource management, and more specifically, to sustainable land management and biodiversity conservation. The pressures of modern change dictated and driven by the northern hemisphere has however, been too fast for Africa to keep pace with, especially given the many pressing priorities that African governments are facing. At the same time, global climate change is making its presence felt ever increasingly all over the planet, including Africa, who may perhaps be the least prepared for the significant challenges that climate change will pose to many African governments. Regarding climate change, the main challenge will be the capacity to cope with and adapt to its consequences. This paper will focus on the development issues facing Africa today, with a special focus on global change and its impacts on soils and development in Africa.

Around 50 years ago, the winds of change blew over the African continent and many African countries obtained their independence from their colonial masters. Many of these countries were just at the beginning of modernisation at independence and together with that, also inherited a vast social and environmental debt.

Many countries were faced with and continue to be faced with rural and urban poverty, skewed distribution of income, and poor education, health and housing for the rural majority. In addition to these problems, there was the quest for development. In this quest for development and modernisation, there was a significant alienation of people from natural resources such as wildlife (plants and animals) on which they depended for their sustained survival and existence. Although the emergence of nature conservation was already visible, it was seen as the responsibility of the government and simply an issue of parks and wildlife management. At the same time, agriculture was seen as a means of transforming the African economy through change from subsistence agriculture to commercial agriculture. Huge tracks of land were thus converted into agricultural lands to produce cash crops for foreign markets.

The African soils are inherently poor and lack essential minerals needed for healthy crops. The soils could cope with subsistence agriculture which, however, was on the decline as many rural farmers shifted towards cash crops. Over the years agricultural productivity declined, however, due to a combination of factors, the major ones being: loss of biodiversity, bush-encroachment, deforestation, overgrazing, soil erosion and loss of fertility of croplands. Another significant contributor to loss of productivity was nutrient mining of African soils. Attempts to remedy environmental conditions resulted in the application of Eurocentric and rigid agricultural policies imposed on a highly variable environment.

1. Africa Today

The policies and strategies employed over the last fifty years on the African continent have had some impacts on the course of development on the continent. There has been headway in addressing some of the problems mentioned above. However, the battle has not yet been won, especially in the environment sector. The problems continue. This time, they are driven and exacerbated by the loss of traditional knowledge, innovations and practices relevant to the conservation and management and sustainable use of biodiversity, globalisation, conflict and war, land and resources tenure, livelihood insecurity and poverty, and, most significantly, population growth.

The rise in population numbers of the African people in particular has had an impact on the ability of African soils to continue to provide. There are more and more mouths to feed and less and less natural resources. The curse of natural resources has also been very evident in those African countries blessed with minerals and other significant natural resources of international importance. This curse has left many countries, which could under other circumstances provide for their nationals and still be left with a surplus of food, unable to do so due to the wars and conflicts that have afflicted them. The next section will take a closer look at African soils.

2. Africa and Her Soils: Can They Save Her?

One of Africa's most urgent issues today is food security; this is amidst all the other development issues that are just as urgent and pressing. Food production in many African states, as mentioned before, is not able to keep pace with the expanding population growth and the ever-increasing demand on diminishing natural resources. This leads to continued declines in its already low food production per capita. Africa is an old continent and as such has also the prevalence of very old soils. Most of Africa's soils are formed from weathered rocks that are low in nitrogen and phosphorous. Dominant clay minerals are such that the nutrient storage capacity of most of the soils is limited. Not only are the soils poor, but the climate is also extreme, rainfall being irregular and erratic or too high and intense. The soils are also characterised by low organic matter content which contributes to the lack of nutrient storage capacity and to low water retention capacity. This is worsened by the fact that African soils are very prone to erosion.

The situation described above has significant implications for agriculture in Africa. Agriculture is a challenge for many African countries. The poor quality of African soils is the most important limiting factor to African agriculture. Agriculture accounts for more than 25% of the Gross Domestic Product (GDP) of most African countries, and is the main source of income for and employment of at least 65% of Africa's population of 750 million. Thus, agricultural development is vital to Africa's economic growth, food security, and poverty alleviation (Henao and Baanante, 1999).

By 2020 Africa is projected to import more than 60 million metric tonnes (t) of cereal yearly to meet demand. Africa's food security situation has deteriorated significantly over the past two decades (Henao and Baanante, 1999). With population growth of about 3% yearly, the number of malnourished people in Africa has grown from about 88 million in 1970 to more than 200 million in 1999-2001.

Conventional agriculture is also hampered in terms of production in much of Africa. This is because of the predominance of fragile ecosystems, low inherited soil fertility, and low use of modern inputs such as mineral fertilizers and improved varieties.

Farmers in sub-Saharan Africa have traditionally cleared land, grown a few crops, then moved on to clear more land, leaving the land fallow to regain fertility. However, today population pressure and thus the more mouths that need to be fed forces farmers to grow crop after crop on the same land, thus raping or mining already poor soils from the remaining nutrients while giving nothing back. With little access to fertilisers, the farmers are forced to bring less fertile soils on marginal land into production, at the expense of wildlife and forests (Henao and Baanante, 1999).

The propensity for nutrient mining of Africa's agricultural land and the severity of its consequences are the highest in the world. Continued nutrient mining of African soils would mean a future of increased poverty, food insecurity, environmental damage, and social and political instability (Henao and Baanante, 1999).

Amidst all these pressures there is the eminent threat of global warming and global climate change as already alluded to above. This in itself will have significant impacts on the ability of Africa to feed her people. Vulnerability to climate change will be a major issue, posing a significant challenge to the sustainable management of Africa's drylands especially in sub-Saharan Africa. Climate change in southern Africa is likely to add only further incremental stress to ecosystems already under pressure due to population growth, increasing subsistence needs, endemic droughts in most of the region, unequal land distribution and very limited coping ability, especially in communal rangelands.

3. Is Agriculture Indeed a Poverty Trap?

From the above it can be argued that agriculture in African drylands may constitute a poverty trap for many of the already marginalised rural poor. It may serve only the interest of the elite rich minorities who are able to afford large tracts of land, the expensive fertilisers and other agricultural inputs. These elites can then provide employment at a pittance to the rural majority. It is thus difficult to see how rural people can become empowered and increase their assets and income by engaging in conventional agriculture in drylands. Perhaps it is time for a new shift away from conventional agriculture in some parts of Africa. This shift will be especially important in African drylands.

4. A New Mindset: Namibian Case

To get to this mind shift, it is important for the rural communities, their development partners, service providers and government officials to consider the comparative advantages for their specific areas within the given parameters of the environmental constraints imposed upon them. The focus should shift to other land use options in addition to conventional agriculture. The focus must be on income and livelihood diversification.

Namibia as an example boasts the following comparative advantages:

- Vast open spaces and wilderness areas;
- Abundant and rich biodiversity and wildlife populations that are well adapted to Namibia's harsh climatic and physical conditions, and have extremely high direct and indirect use value;
- Uncontaminated meat and fish products;
- Rich cultural diversities and valuable traditional knowledge;
- Efficient service industries.

The above comparative advantages enables Namibia to engage in a number of indigenous biodiversity production systems within the parameters of Namibia's harsh, dry, climatic and physical conditions. Examples of these activities are:

a) Bio-trade and bio-prospecting and natural product development

This constitutes the search for interesting bio-molecules and other pharmaceuticals and natural products. Namibian stakeholders have developed and refined an innovative coordinated approach to proactively create sustainable economic opportunities based on harvesting, processing and trading in indigenous plants/natural products. Namibia has already successfully completed a number of new bio-trade products and has a number of projects aimed at finding new opportunities together with local communities. Examples of these are the export of Hoodia, Marula oil, Ximenia oil, Devils Claw (*Harpagophytum Procumbens*), wild silk, Kalahari melon seed oil and a range of other natural products.

b) Sustainable eco-tourism

Namibia's vast open spaces, wilderness areas, scenic landscape, significant numbers of wildlife (plants and animals) and her deserts (the Namib Desert on the west and the Kalahari Desert on the east) provides opportunities for excellent tourism potential. The challenge is how to involve the rural majority in tourism development as opposed to leave it entirely up to the private sector. The Namibian government has promoted Community Based Tourism and Community Based Natural

Resource Management extensively. Income and other benefits have accrued to many communities who were encouraged to get involved in various tourism initiatives in combination with natural resources management.

c) Community Based Natural Resource Management

The Namibian government has further initiated policy and legal framework adjustments that have devolved rights over wildlife and natural resources to organized Community Based Natural Resources Management (CBNRM) groups. These groups fall under two categories, one known as Conservancies and the other as Community Forests. These are most prevalent in Namibia's most marginalised rural areas. These initiatives have had a significant impact on the livelihood of community members and has provided them with unprecedented incentives to manage and conserve their wildlife and areas, but also most importantly it demonstrated the user value of natural resources and the economic benefits that accrued to communities. In turn, this resulted in mass recovery of game populations outside national parks. Community members can thus derive benefits from trophy hunting, the sale of non-timber forest products and other tourism-related activities.

d) Game and game meat products

The potential of Namibia to provide world class venison and other game meat products is virtually untapped so far. Most of Namibia's game meat is consumed within the local market whereas the international market may provide significant returns if managed properly. Namibia has done well in terms of the management of game stocks and has seen significant increases in the number of game on communal lands, commercial land and state land as a result of innovative policy and legal instruments. Namibia can thus afford to create local, regional and international markets based on game and relying on the comparative advantage of organically sourced and uncontaminated venison.

5. A New Paradigm

The Namibian experience has elucidated that a paradigm shift from a focus on only conventional agriculture to initiatives such as sustainable eco-tourism provides for effective and sustainable development in dry areas. It provides for, amongst other things:

- New hope and job opportunities for the rural majority;
- A profound change to local economy;
- More jobs and especially an improvement in job opportunities for women;
- Reasonably well-paid jobs;
- An increase in education levels;
- An increase in land value;
- An increase in people's sense of caring for the land and wildlife;
- Tourism as the only means of subsistence for many;
- People taking pride in their traditional products which are now marketed in formal markets;
- Recognition of the value of traditional knowledge, innovations and practices; and
- Empowerment of people to take their own future into their own hands.

It has also become apparent during the last five years that wildlife, tourism and other indigenous biodiversity production systems are now the most economically important forms of large-scale land use in Namibia. The value of the land adjacent to national parks has gone up significantly when used for wildlife and tourism as opposed to farming. Agricultural production for the year 2005 in terms of income was much lower compared to that of indigenous biodiversity-based production (see Tables 1 and 2[1]).

Table 1. Agricultural Production – 2005.

Commodity	Output value (million N$)	
	Commercial	Communal
Cattle	637.1	5.8
Small stock (sheep & goat)	285.1	
Other livestock (pigs, dairy, karakul, hides & skin)	258.2	
Crops (cereals, grapes, etc.)	188.7	154.5
Other agriculture		290.0
Construction for agriculture	59.0	
TOTAL	1,878.4	

[1]The data provided here has been provided by the Namibia Nature Foundation.

Table 2. Indigenous Biodiversity-based Production – 2005.

Commodity (Commercial only)	Output value (million N$)
Trophy hunting	316.0
Live game sales	14.3
Wildlife viewing	2,700.0
Fuel wood sales	63.0
Charcoal	75-100
Selected plant products	21.6
TOTAL	3,200

It has also become clear over the years that conventional farming in drylands will never make people and countries rich – in arid zones, farming is a poverty trap especially for the already poor and marginalised rural majority. The Namibian experience has demonstrated that wildlife, tourism, etc., have the demonstrated potential to create much more wealth, employment, improved livelihoods and development of skills, and can provide people with a set of options (Shikongo, 2007).

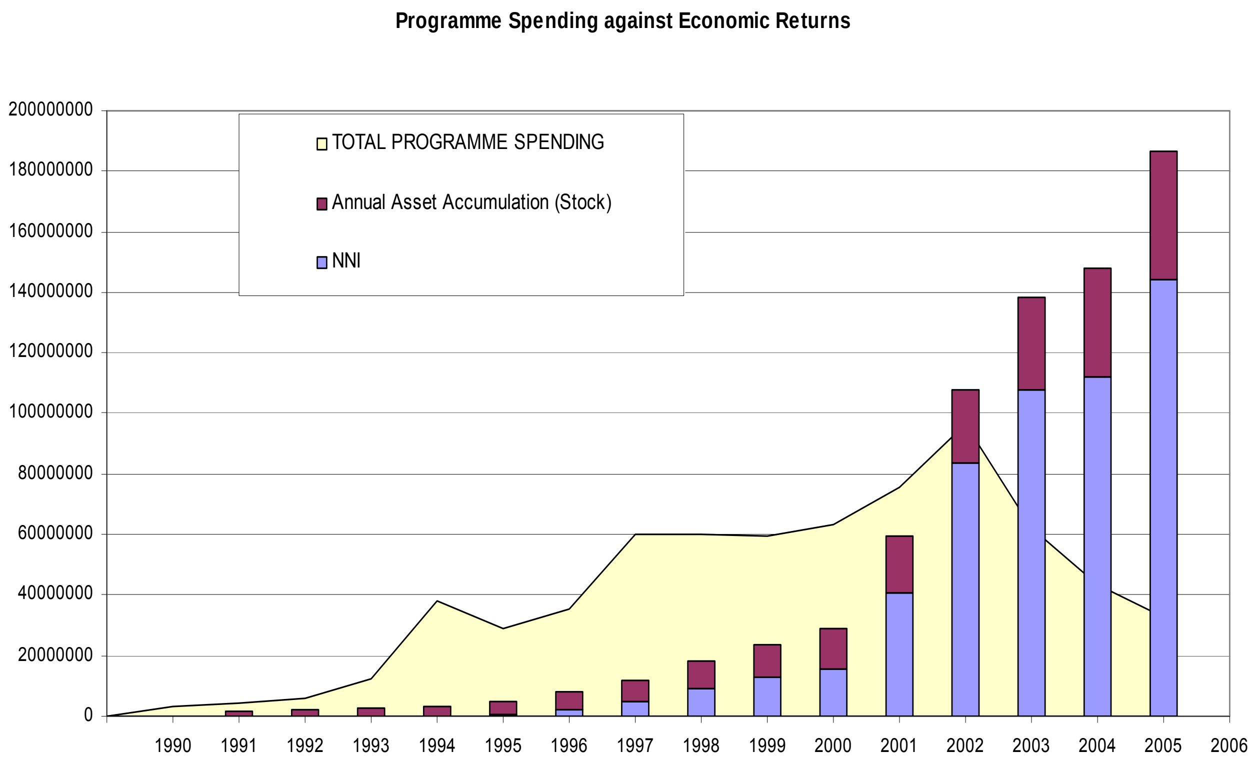

Figure 1. Programme Spending against Economic Returns in Namibia.

It has to be pointed out that this transformation needs a combined effort by the rural majority themselves, the government, community service providers, and the private sector. It also requires a significant financial and capacity development investment over time, and with time the income generated will become significantly higher than the initial investment and the community will see a build-up of real assets. Figure 1 illustrates this point, as it summarises the CBNRM programme spending in Namibia. The initial financial investment, be it from donors, public funds, the private sector, or public-private partnerships, can be regarded as seed funds or low hanging fruits[2], which provide room for bigger fruits later on (Figure 1).

Conclusions

For Namibia, tourism and wildlife has provided a significant comparative advantage to conventional agriculture. It is now up to Namibians to take care of this advantage and to manage and use it sustainably. Other dryland nations will have to

[2]The concept of low hanging fruits refers to interventions that provide the basis for further larger interventions. Thus, the initial funding is used to find ways to reap small benefits, which in turn reap the higher hanging fruits, i.e. the larger benefits.

determine their comparative advantages and work with them to create a meaningful livelihood and empower their people to reach greater heights.

Finally, it is important to point out that the strongest incentives for wise and sustainable use of dryland wildlife and indigenous biodiversity production systems and their long-term conservation are created by these resources having a high and tradable value – the higher the value the better.

References

Henao J, C.A. Baanante, 1999. *Nutrient Depletion in the Agricultural soils of Africa*. International Food Policy Research Institute (IFPRI).

Shikongo, Sem T., 2007. *Sustainable Eco-tourism as Sources of Income in Drylands: Lessons from Namibia*. Global Interactive Dialogue, Buenos Aires, Argentina.

Iceland's Century of Conservation and Restoration of Soils and Vegetation[1]

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Introduction

The 1100 years of human settlement in Iceland have been marked by extensive soil erosion and a large scale degradation of terrestrial ecosystems. This has had a wide ranging effect on these systems and people's livelihoods. To stop the destructive forces, a unique legislation was passed by the Icelandic Parliament in 1907 aimed at halting soil erosion and restoring lost and degraded woodlands: the *Act on Forestry and Protection against Soil Erosion*.

Iceland's 100 years of such national operation are characterized by numerous success stories of stabilizing desertified land and restoring land quality (Olgeirsson, 2007). However, the task of protecting and restoring Icelandic ecosystems is still enormous. The aim of this paper is to describe some of the important lessons that can be drawn from the long history of land degradation in Iceland, and the country's century-long effort of soil and vegetation conservation and restoration of damaged land.

1. Human Settlement and Subsequent Land Degradation

The nakedness of many parts of Iceland may be regarded as one of its most striking features. Most of this reflects a millennium-long damage to ecosystems caused by the interaction between unsustainable land use and natural forces in a sensitive environment.

The first human inhabitants were met by lush vegetation and fertile ecosystems. Up to two-thirds of the country may have been vegetated and at least 25% of the area was covered with woodlands, mainly birch (*Betula pubescens*) (Arnalds, 1988). The country became settled by Scandinavian Vikings around AD 874. The short Settlement period and the subsequent Commonwealth period – the first few centuries of human history in the country – was a time of prosperity. Human population density soon increased, increasing the pressure on the land.

There are several indications that land decline was triggered and greatly accelerated by settlement. The woodlands were cut for fuel and timber, or burned to provide space for agriculture and grazing. As their distribution and cover reduced and grazing pressure increased, the sensitive volcanic soils lost their shelter and became more vulnerable to the erosive forces of wind and water. Ash and tephra from frequent volcanic eruptions started blowing over the surface, damaging the sward and further exposing the soil and vegetation to these forces of destruction. Cooling temperatures reduced the capacity of the vegetation to recover. Thus, it is believed that the coupling effects of human-induced activities and natural forces to a large extent caused the great deterioration that Iceland faces today (Arnalds, 1987).

The peak of the ecosystem destruction may have been reached in the late 19th century, caused by the interaction of increasing livestock numbers and climatic fluctuations. Without adequate incentives for conservation, this severe degradation lasted until a few decades ago. Catastrophic soil erosion and desertification has damaged ecosystems in large parts of the country. Arnalds (1988) summarises some of the various sources that can be used to reconstruct the vegetation of the past and trace some of the major changes in cover and composition through the centuries. These include historical records, site names, pollen studies, remnants of former vegetation and land use indicators. About half of the vegetation may be lost, with the clearest example being the extensive deforestation of the birch woodlands. Only about 5% of these woodlands still remain. A national survey on the extent of soil erosion revealed that serious soil erosion characterizes about 40% of Iceland (Arnalds et al., 2001). Much of the remaining vegetation is severely degraded, biological diversity reduced, land fertility diminished and hydrology altered.

2. Initiation of Efforts to Combat Soil and Vegetation Loss

Repeated disastrous events occurred in the last decades of the 19th century. Sandstorms in the early 1880s were especially harmful, and numerous farms were decimated by the erosion (Olgeirsson, 2007). This catastrophe triggered some action against the destruction. In 1895, the first formal and organized measures aimed at curtailing erosion were taken with the *Act for Resolution on Sand Erosion and Reclamation* passed in the Icelandic Parliament. However, the effect of this legislation was negligible and of little value since it provided no means or incentives for erosion control (Runólfsson, 1987).

The first tangible fruits of the first actions against soil erosions in Iceland was the *Act on Forestry and Protection against Soil Erosion*, passed by the Icelandic Parliament in 1907. This marked the beginning of organized battle against the erosion. By later amendments of this law, two state institutes were subsequently established: the Soil Conservation Service (SCS) and the Forest Service (FS) of Iceland. Both have emphasized conservation of soils and vegetation; the SCS is primarily concerned with soil erosion control and revegetation, but the FS is responsible for protection of the remaining birch woodlands, reforestation and afforestation.

[1]This paper is based on the presentation "Iceland and the Global Picture" given by Andrés Arnalds on 31 August 2007 and the presentation "Iceland's Century of Conserving and Restoring Soil and Vegetation" given by Sveinn Runólfsson on 4 September 2007 at the International Forum on Soils, Society & Global Change.

3. Lessons from the Past

During the 100 years of soil conservation in Iceland, much has been achieved in the battle against soil erosion, despite limited resources during most of this time. The first sixty years were almost entirely devoted to the urgent task of halting sand dune advance and other forms of catastrophic soil erosion and vegetation destruction in pastures and rangelands that left barren deserts behind and threatened the existence of several communities (Arnalds, 2005a). By the late 1950s, the most serious sand drifts had been halted (Runólfsson, 1987) and many districts and farms saved from destruction (Olgeirsson, 2007). This work was mainly conducted by fencing off areas of severe erosion and seeding the native sand stabilizer, *Leymus arenarius*, the only native plant capable of halting moving sand in Iceland (Runolfsson, 1987).

By the 1950s, when sand encroachment had become a lesser threat to inhabited areas and with more availability of fertilizers and better equipment, revegetation of some of the vast areas of denuded land slowly began. Experiments on the use of a variety of exotic grass species for revegetation led to a large-scale seeding of grass species and fertilization (Magnússon, 1997), largely by means of aerial distribution using aircrafts (Runólfsson, 1987). Initially, grasses such as *Festuca rubra* and *Poa pratensis* were seeded and the area fertilized for 3-4 years with 300-400 kg/ha of a mixed N-P fertilizer. The use of this method has turned out to be successful in improving site conditions and speeding up the natural processes of recovery. The grasses start disappearing soon after fertilization ceases, and species from adjacent native vegetation start colonizing. The direction and rate of this secondary succession depends on many factors, including availability of seed sources in adjacent areas. Since 1990, lower amounts of fertilizers (150-200 kg/ha) have mostly been used, and it is becoming increasingly common to stimulate natural recovery using only fertilizers and no grass seeding.

The fight against the rapidly encroaching sand dunes and other forms of immediate destruction was highly successful, especially considering limited financial and human resources. Many districts and towns were saved from the sand storms (Olgeirsson, 2007). However, in retrospect, the first 70-80 years of SCS activities only managed to treat a small proportion of the affected areas and vegetation is still being lost through erosion today. In addition to limited financial resources, Arnalds (2005b) argues that reasons for the inadequate achievements on a national scale until after about 1990 may include:

- The soil conservation work was too localized, as only the spots of the most severe erosion and desertification were being treated;
- The conservation approach was too narrow, emphasizing single issue approaches, as the focus was on halting the erosion, not on preventive measures on a landscape basis;
- Low conservation awareness resulted from the lack of land user and public involvement, as the government conducted most of the work with its own personnel and machinery;
- Insufficient inventories existed on the state of the natural resources and on cause and effect relationships, leading to unfertile debates between land users and conservation people on the seriousness of the soil erosion problems and the role of land use in the land degradation;
- Governmental subsidies to sheep production were lacking environmental links. A high level of support led to an all-time peak in sheep numbers in the late 1970s, but poor grazing management resulted in severe overgrazing in many areas. The government was paying at both ends, indirectly for the damage to the land, and directly for its reparation;
- Weak laws on soil conservation, meaning that the SCS had no actual means to enforce proper protection of sensitive soils and vegetation. Theoretically, maximum numbers of livestock grazing in a given area could be decided where needed, but the legal procedure was (and still is) too complex, rendering this option for preventive measures useless.

The mixed success of the early soil conservation work was influenced by many other factors, such as various sociological barriers to improved conservation. A general lack of incentives to care for the land, and similarly, a lack of disincentives to reduce unsustainable use, prevailed until recently (Arnalds, 2005b). Similar experiences have been described for many other countries. The top-down approach, lack of local involvement and “curing symptoms rather than causes” are amongst organizational and strategic mistakes that were frequently seen in many other, widely differing countries (Roberts, 1989; Douglas, 1996; Hannam, 2000; Sanders, 2000).

4. A Shift in Conservation Approach

It is clear that in order to prevent further damage to Iceland’s ecosystems and to reclaim lost resources, a comprehensive framework is needed, based on long-term goals. Laws that affect land use and condition need to be harmonized; supporting factors such as research, planning, evaluation, outreach and education need to be strengthened; and incentives aimed at stimulating knowledge, awareness and conservation ethics need to be promoted. A lot can be adopted from international conventions and agreements that Iceland has already committed to.

A step in building such a framework was taken in 2002 when the Parliament of Iceland decided on a comprehensive programme, giving the SCS an operational framework for the period 2003-2014. This programme sets goals for mitigation of land degradation and desertification, revegetation of eroded land, and attaining sustainable land use. The main tools for the programme’s achievements were described, and financing improved substantially, mainly for halting desertification, extending farmer involvement in healing the land, and by establishing a new land care incentives programme that was mainly intended for projects at the communal or co-operative level.

Since 1990, the SCS has increasingly promoted and initiated participatory approaches to soil conservation. Arnalds (2005a) argues that this has markedly increased the adoption and success of conservation projects. During this period, the soil conservation work has developed towards ecosystem management for multiple uses. The following describes the change in the conservation approaches that have gradually been adopted for soil conservation in Iceland.

4.1. Sustainable land use

The Icelandic experience illustrates that ecological sustainability of grazing and other land uses is a large determinant of land health. Most of the island is accessible for grazing, but land condition is poor over large areas. In areas of severe land degradation and desertification, grazing can have a dramatic effect. In many other degraded or denuded areas, livestock grazing can significantly slow vegetation recovery. Major management changes are needed in many areas of Iceland in order to reach goals of sustainable land use.

Sheep, and now increasingly horses, are the major large grazing animals in Iceland. Steps towards increased ecological sustainability must therefore carefully consider sheep production, grazing management and governmental agricultural support. Sheep production in Iceland is costly, mainly as a result of a long indoor feeding period in winter, and has been receiving a high level of governmental support. To meet public concerns and give the land users a larger conservation role, the current contract between the sheep producers and government now has a partial link between agricultural support and environmental conditions. Starting in 2003/2004, farmers must verify the ecological sustainability of their operation with the SCS in order to obtain a full subsidy (Arnalds and Barkarson, 2003). Farmers who do not meet certain standards must submit a conservation and land improvement plan for SCS approval. This policy has become an important measure towards increased land use responsibility of sheep farmers in Iceland, and a big stimulus for improvement of land condition.

Horse grazing is also an important, but in most cases more localized, determinant of land health. A voluntary ‘bottom-up’ quality control of sustainability is emerging in this sector. Other concerns include crop production, which has been limited in Iceland. However, with new strains of barley and a more favourable climate in recent years, crop acreages are rapidly increasing. A new soil conservation concern is therefore emerging in Iceland, especially with regards to tilling.

4.2. Involving land users and the public

Since 1990, there has been an increasing participatory approach to soil conservation in Iceland. This has markedly increased the adoption and success of conservation projects (Arnalds, 1999).

To increase participation of farmers in soil and vegetation conservation, the SCS operates two main programmes for financial support:

The *Farmers Heal the Land* project includes a ‘cost-share’ partnership with farmers, with conservation work jointly funded by the government and farmers. Using their machinery, own labour and about 15% of fertilizer cost, the farmers’ share may average around 50% of project cost. This ‘bottom-up’ approach encourages involvement and individual ownership of conservation projects. This approach has been important in building mutual trust between farmers and conservation authorities, which is a foundation for resolving many other issues. Participants have also been active in developing new methodologies, in cooperation with the soil conservationists, greatly advancing the knowledge base for local soil conservation.

The *Land Improvement Fund* was initiated in 2003. By providing financial support, this programme aims to shift responsibility, initiative and execution of the soil conservation work to local authorities, land owners, non-governmental organizations and other interest groups.

A participatory programme termed *Better Farms* has been evolving, aimed at good farming practices and sustainable land use planning. The programme’s goal is to combine the forces of soil conservation, forestry, extension and nature conservation in assisting land users to produce their own property plans. Another aim of the programme is to make farmers the active partners in the planning process, and to improve co-ordination between the various institutes and organizations that work with farmers. The participants of the programme are provided with good quality aerial photographs and taught the elements of reading the land, information seeking, and developing their own plans.

The SCS has also greatly emphasized working with rural and urban authorities concerning grazing management and revegetation issues. A wide range of clubs and associations, along with individual volunteers, have become active in various aspects of the conservation work. Working with such groups can be important in bridging the divide between rural and urban communities.

4.3. Skills and conservation ethics

There are many factors that influence the long-term success of the protection of natural resources. Awareness, skills and conservation ethics building on scientific and practical knowledge are very important in this regard. Therefore, in the Icelandic 2003-2014 parliamentary approved soil conservation programme, research, education and knowledge transfer are among the key elements.

The SCS operates research, land information, and public relations departments that work closely with other agencies. Education related to soil conservation issues is a fundamental part of the institute’s work: in schools, with the public and in other sectors. The increase in participatory action has resulted in much better cooperation with land users. Among future objectives is to ensure that all government-funded services to agriculture incorporate due respect for the goal of sustainability.

4.4. Financing

The urgent task of healing the land in Iceland is a major challenge for a nation of only 320,000 people. In addition to government funding, farmers, volunteers and clubs, district authorities, and a number of other interest groups provide significant contributions towards the soil conservation work in Iceland. A large contributing donor is the Retailer Association of Iceland, which finances many conservation programmes with revenues generated by charging for plastic grocery bags in their stores. Further means of financial support for restoring degraded land in Iceland is urgently needed.

5. Iceland and the Global Picture

The silent crisis of ecosystem degradation, soil erosion and desertification is seriously affecting a growing proportion of the human population (UNCCD, 2008, Millennium Ecosystem Assessment, 2005). Despite the important linkages with a multitude of environmental, economic and social issues, – such as climate change, biodiversity, water supply, food security, poverty reduction and world peace – the severity of these problems and the need for land restoration are not gaining enough attention.

Iceland demonstrates clearly the vicious cycle of unsustainable land use, reduced land quality, and the struggle for survival that still further fed the loop of desertification in a subsistence-farming culture until the early twentieth century. The main underlying causes of the massive land degradation are the same as in many other parts of the world: clearing of land by burning, too much harvesting of trees and scrubs, and overgrazing that weakened the resilience of the ecosystems and hampered regeneration after disturbances.

The environmental consequences also have many parallels: large-scale changes in biological diversity, reduction in water holding capacity of the land, and loss of organic matter and nutrients. Changes in weather patterns at local and regional levels are probable.

Though the cost of the degradation has not been assessed, it results in a large-scale reduction in the number of ecosystem services provided, leading to less efficient and more costly agriculture, loss of shelter from wind and snowdrift, and more extremes in the flow of streams and rivers.

Every country has its own sets of solutions for resolving the land degradation problems and attaining goals of sustainable land use. Icelandic experience demonstrates the failure of ‘top-down’ approaches and the importance of helping people conserve and heal the land. Participation is now a main characteristic of soil conservation and land restoration in Iceland, and the success stories are an encouragement for other countries to adapt such land care approaches (Arnalds, 2005a, Olgeirsson, 2007).

Land restoration has an important role in reaching Iceland’s targets in mitigating climate change. Carbon dioxide (CO_2) is the most important greenhouse gas actor in climate change. The carbon atom located in soil as organic matter is the key to soil fertility, food production and other ecosystem services. Iceland has lost immense amounts of carbon due to ecosystem degradation and soil erosion, and there is an urgent need to return some of this carbon back to the land, recharging the ecosystems. Restoration of land quality by revegetation, reforestation and afforestation may increase carbon storage by millions of tonnes of CO_2 equivalents and improve land for future generations. Combined with Iceland’s many options for the urgent task of reducing emissions of greenhouse gases, Iceland could become a carbon neutral country within a few decades – a model country in caring for the environment (Arnalds 2004, Agústsdóttir et al., 2008).

Even if the human population were to cut emissions of CO_2, the decay of atmospheric CO_2 is slow, and climatic changes would still occur. Iceland’s experience shows how carbon projects can be planned for multiple benefits, generating income streams for the restoration of land quality.

In the 100 years of halting soil erosion and restoring ecosystem function in Iceland, much experience and knowledge has been gained, giving Iceland an important role in cooperation with other countries. This long-term experience forms the basis for a Land Restoration Training Programme that the Ministry for Foreign Affairs is financing as part of its development cooperation programme, following the lead of the successful United Nations University training programmes in geothermal energy and fisheries in Iceland.

Lastly, with the wide-ranging consequences of soil erosion in Iceland, and the multiple benefits of restoring land quality, the Icelandic experience demonstrates that soil is the vital, but often overlooked, link between environmental issues and the goals of the key environmental Conventions. Let us build the bridges, and not forget the soil.

References

Agústsdóttir, A. M., A. Arnalds and A. Bragason, 2009. “Can Iceland Become a Carbon Neutral Country by Reducing Emissions and Restoring Degraded Land?” in Bigas, H., G.I. Gudbrandsson, L. Montanarella and A. Arnalds (eds.) *Soils, Society & Global Change: Proceedings of the International Forum Celebrating the Centenary of Conservation and Restoration of Soil and Vegetation in Iceland, Selfoss, Iceland, 31 August – 4 September 2007*. European Commission – Joint Research Centre, Italy., p.142-148.

Arnalds, A., 1987. “Ecosystem Disturbance in Iceland”. *Arctic and Alpine Research,* 19(4): 508-513.

Arnalds A., 1988. “Landgæði á Íslandi fyrr og nú [Land resources in Iceland, past and present]” in *Icelandic SCS Yearbook*, 1, pp. 13-31 (in Icelandic).

Arnalds, A., 1999. “Incentives for Soil Conservation in Iceland” in (eds.) D. Sanders, P.C. Huszar, S. Sombatpanit and T. Enters, *Incentives in Soil Conservation*. Science Publishers, Inc., Enfield, New Hampshire, on behalf of WASWC, IBSRAM, SWSCT, and DLD, Bangkok, pp.135–150.

Arnalds, A., 2004. “Carbon Sequestration and the Restoration of Land Health” in *Climate Change,* 65(3): 333-346.

Arnalds, A., 2005a. “Approaches to Landcare – A Century of Soil Conservation in Iceland” in *Land Degradation & Development*, 16, pp. 113-125.

Arnalds, A., 2005b. “Barriers and Incentives in Soil Conservation – Experiences from Iceland” in *Strategies, Science and Law for the Conservation of the World Soil Resources*. Agricultural University of Iceland Publication No 4, pp. 251-259.

Arnalds, Ó. and B.H. Barkarson, 2003. “Soil Erosion and Land Use Policy in Iceland in Relation to Sheep Grazing and Government Subsidies” in *Environmental Science & Policy*, 6, pp. 105-113.

Arnalds, Ó., E.F. Thorarinsdóttir, S.M. Metusalemsson, A. Jónsson, E. Grétarsson, and A. Árnason, 2001. *Soil Erosion in Iceland*. Soil Conservation Service and Agricultural Research Institute, 157 pp.

Douglas, M., 1996. “A Participatory Approach to Better Land Husbandry” in (eds.) S. Sombatpanit, M.A. Zöbisch, D.W. Sanders and M.G. Cook, *Soil Conservation Extension from Concepts to Adoption*. Soil and Water Conservation Society of Thailand, pp. 107–121.

Hannam, I.D., 2000. “Soil Conservation Policies in Australia: Successes, Failures and Requirements for Ecologically Sustainable Policy” in (eds.) E.L. Napier, S.M. Napier and J. Tvrdon, *Soil and Water Conservation Policies and Programmes: Successes and Failures.* CRC Press, Boca Raton, Florida, pp. 493–514.

Magnússon, S.H., 1997. “Restoration of Eroded Areas in Iceland” in (eds.) K.M. Urbandska, N.R. Webb, and P.J. Edwards, *Restoration Ecology and Sustainable Development*, Cambridge University Press, pp. 188-211.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Desertification Synthesis*. World Resources Institute, Washington, D.C.

Olgeirsson, F., 2007. *Sáðmenn sandanna*. [A Centennial of Soil Conservation in Iceland]. Soil Conservation Service of Iceland, 250 pp (in Icelandic).

Roberts, R., 1989. *Land Conservation in Australia. A 200 Year Stocktake*. Soil and Water Conservation Association of Australia, pp. 32.

Runólfsson, S., 1987. “Land Reclamation in Iceland” in *Arctic and Alpine Research*, 19, pp. 514–517.

Sanders, D.W., 2000. “The Implementation of Soil Conservation Programmes” in (eds.) O. Arnalds and S. Archer, *Rangeland Desertification*. Advances in Vegetation Sciences Series. Kluwer, Dordrecht, The Netherlands, p143–151.

UNCCD, 2008. *Desertification, land degradation, drought bring rising hunger and agricultural bankruptcy.* Press release. Available at: http://www.unccd.int/publicinfo/docs/PressReleaseeng.pdf.

Session 2:
Healthy Soils – Supporting Food Security, Water Provision, Poverty Reduction and Biodiversity

Agriculture, Land and the Global Environment

Parviz Koohafkan, Food and Agricultural Organization of the United Nations

Introduction

Entering the new millennium, stark contrasts exist between the availability of natural resources and the demands of billions of humans who require them for their survival. Each day, almost a quarter-million people are added to the roughly 6.4 billion that already exist. Yet the stocks of natural resources that support human life – food, fresh water, quality soil, energy and biodiversity – are being polluted, degraded and depleted (Pimentel & Wilson, 2005).

Agriculture is the world's largest single industry; it employs 1.3 billion people, and produces US$ 1.3 trillion worth of goods per year (FAO, 2000; UNDP et al., 2001). Agriculture employs more people and uses more land and water than any other human activity. It has the potential to degrade the Earth's land, water, atmosphere and biological resources – or to enhance them – depending on the decisions made by the more than two billion people whose livelihoods depend directly on crops, livestock, fisheries or forests (FAO, 2007a).

Over the past 40 years, per capita world food production has grown by 25% (Figure 1) and food prices in real terms have fallen by 40% until the year 2007. Since then, there has been a sharp increase in world food prices due to various factors, including: bad harvest in the main cereal producing countries; increase in oil prices; and, strong demand for the production of biofuels (FAO, 2007). Between the early 1960s and mid-1990s, average cereal yields grew from 1.2 t/ha to 2.52 t/ha in developing countries (1.71 t/ha on rain-fed lands and 3.82 t/ha on irrigated lands), whilst total cereal production grew from 420 to 2121 million tonnes per year (FAO, 2007b).

Despite such advances in productivity, the world still faces a fundamental food security challenge. According to most recent data (FAO, 2006a) there are an estimated 854 million people hungry and lacking adequate access to food, of whom 31% are in East and South-East Asia, 31% in South Asia, 25% in sub-Saharan Africa, 7.6% in Latin America and the Caribbean, and 5% in North Africa and Near East.

Food demand will both grow and shift over the next two decades (Figure 1). There are three driving forces:

(i) increasing numbers of people – as total population will continue to increase until at least the latter part of the 21st century, the absolute demand for food will also increase;

(ii) increasing incomes means people will have increasing purchasing power (even though many people will remain on no more than $1/day);

(iii) increasing urbanisation will cause people to become more urbanised, and therefore more likely to adopt new diets, particularly consuming more meat.

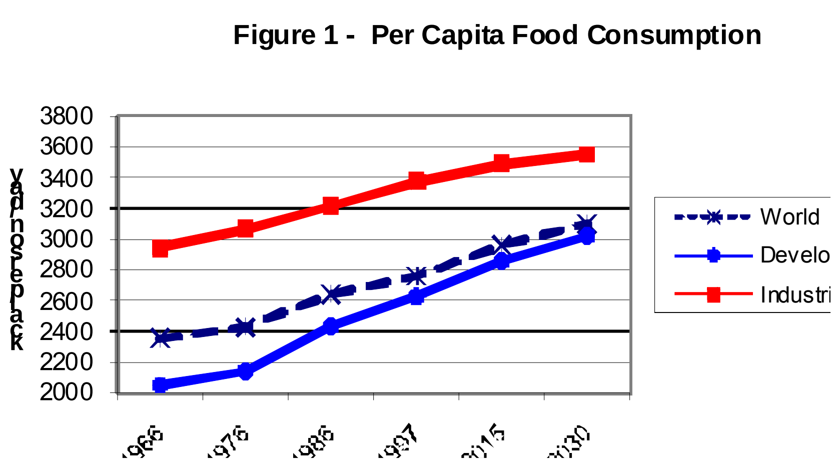


Figure 1. Per capita food consumption since 1964 and projected consumption until 2030 shown for the world, developing countries and industrialized countries. Source: FAO, 2000.

It is predicted that these driving forces will result in a substantial increase in demand for cereals and meat products. China is forecast to account for 25% of the global increase in demand for cereals and 40% of the increase in demand for livestock products (FAO, 2006a).

The future of cereals will change dramatically as technological developments in biofuels and the increasing cost and availability of oil has resulted in some cereals being used to produce ethanol for fuel (principally maize – also sorghum and wheat), notably in USA and China. Although it is too early to determine the full impact this development will have on the supply and cost of food, the fact that food systems and fuel systems are competing for cereals is an historic development that could have unintended environmental, social and food security consequences of major importance.

1. Land Use and Food Production

Globally, the Food and Agricultural Organization of the United Nations (FAO) has identified 11.2 billion hectares of distinct bioproductive areas – cropland, forest, pasture, fisheries, and built-up land – that provide economically useful concentrations of renewable resources. These 11.2 billion hectares cover a little under one-quarter of the planet and include 2.3 billion hectares of marine and inland fisheries and 8.8 billion hectares of land. The land area is comprised of 1.5 billion hectares of cropland, 3.5 billion hectares of grazing land, 3.6 billion hectares of forest, and an additional 0.2 billion hectares of built-up land assumed to occupy potential cropland (FAO, 2006b). Land is more than just soil: it also refers to terrain forms, near-surface climate and hydrology, and plant and animal populations. It includes modifications, favourable and adverse, brought about by human activity. Land is considered not only as a resource but also as a complex dynamic system where soil, water, plants, animals and people interact within a specific biophysical and socio-economic environment.

In 1990, about 1.4 billion hectares of land were under cultivation worldwide, reflecting a five-fold increase in cropped area since 1700 (Figure 2). But the rate of expansion in arable land – currently less than 0.2 percent per year – is declining steadily. While an estimated 100 million hectares of land are newly cultivated each year, a roughly equal area is lost to other human uses or becomes too degraded to farm.

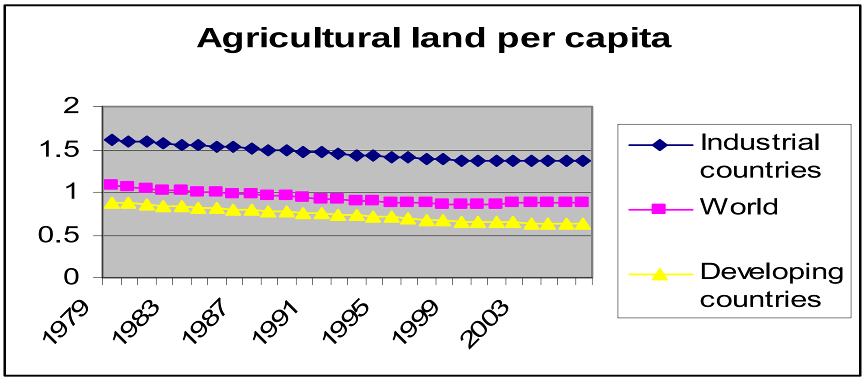


Figure 2. Agricultural land per capita from 1979-2003 for the world (squares), developing countries (triangles) and industrialized countries (diamonds). Source: FAO, 2007b.

The "new lands" are also usually of lower quality. Each year, about 25 billion metric tonnes of nutrient-rich topsoil is dislodged by wind and rain, most of it eventually finding its way into waterways (FAO et al., 2005). Moreover, the soil that is left is less able to hold water and can eventually become too dense for roots to penetrate. Also the salinization – the build-up of salts and other minerals in the soil – is a growing problem for the one-sixth of the world's crop land that is irrigated, and which produces more than a third of all crops and half of all cereal grains. Modern agricultural methods, while responsible for dramatic increases in food production over the last few decades, rely heavily on man-made fertilizers and pesticides that can harm not only the water-retaining quality of soil, but the beneficial organisms and the purity of drinking water as well. The population growth, rapid economic development, agricultural intensification, climate change and increasing demand for biofuels are putting environmental resources and critical ecosystems under untenable pressure throughout the world.

In developing countries, some 2.8 billion ha of land is potentially available for agriculture. Of this, some 960 million ha are already cultivated and most of the remaining land (1.8 billion ha) is unevenly distributed in a few countries in South America and sub-Saharan Africa. However, much of these lands are covered by forests or are classified as marginal lands. Moreover, many of the high-density population countries in South Asia, the Near East and North Africa do not have any significant areas of land left suitable for agricultural development.

With the development of bioenergy, it is likely that land use will continue to intensify and land resources will be increasingly threatened also as a result of fragmentation of landscapes, loss of habitats, and conversion of forest to agriculture and intensification of production systems. In many low-income, food-insecure countries with high population growth and incidence of rural poverty, the number of people seeking to earn a living from agriculture is growing. The continuous decline in available land and water per capita constitutes a threat to food security and welfare, especially where rural populations rely on land resources for a living. Land scarcity and inequality of access to land, water and other resources tend to push rural poor into marginal and ecologically fragile areas with serious constraints to sustainable use.

The annual food expenditure of the most vulnerable countries has more than doubled since 2000 according to FAO estimates (FAO, 2007a). Soaring petroleum prices have contributed to the increase in prices of most agricultural crops: by raising input costs, on the one hand, and, on the other hand, by boosting demand for agricultural crops used as feedstock in the production of alternative energy sources (e.g. biofuels). National policies that aim to reduce greenhouse gas emissions are behind the fast growth of the biofuel industry. Rising fossil fuel prices and attempts to reduce dependence on imported oil, however, have provided the extra incentive for many countries to opt for even more challenging crop production targets. The combination of high petroleum prices and the desire to address environmental issues is currently at the forefront of the rapid expansion of the biofuel sector: this is likely to boost demand for feedstock, most notably, sugar, maize, rapeseed, soybean, palm oil and other oil crops as well as wheat for many more years to come. However, much will also depend on the supply and demand fundamentals of the biofuel sector itself (FAO, 2007b).

2. Land and Poverty

Of the world's 850 million hungry, 95% are concentrated in developing countries (Figure 3), mostly in rural areas. And of the world's 1.1 billion extremely poor people, 75% live in rural areas and depend largely on agriculture, forestry, fisheries and related activities for survival (FAO et al., 2005). Despite large-scale urbanization, extreme poverty continues to be mainly a rural phenomenon. For the rural poor, globalization and the increasing pressures of large industry, markets and urban consumers have, on balance, been detrimental in many places. These trends have forced small producers and farm families out of agriculture or led them to excessive intensification and specialization and increased vulnerability to price fluctuations, the vagaries of weather and pest and disease outbreaks. In developing countries, a mere 4% of official development assistance goes to agriculture. In sub-Saharan Africa, a region heavily reliant on agriculture for overall growth, public spending for farming is also only 4% of total government spending and the sector is still taxed at relatively high levels. For the poorest people, Gross Domestic Product (GDP) growth originating in agriculture is about four times more effective in raising incomes of extremely poor people than GDP growth originating outside the sector (WDR, 2007). Tariffs, subsidies and other trade-distorting policies in developed countries have eroded the market share and revenues of exports by many developing countries. Competition between agriculture and other sectors for land and water, land degradation and desertification, climate change, and loss of biological diversity have transformed the availability and use of natural resources, particularly in those fragile and critical ecosystems where poverty and hunger often prevail. Reliance on currently prevailing patterns of growth will postpone the resolution of poverty in such areas indefinitely, with severe consequences not only for the local people and the countries concerned, but also for the world as a whole. Rural women play a key role in on- and off-farm activities in developing countries. This is particularly true in the case of ecologically fragile areas. With the growing male emigration from marginal areas, the number of female-headed households in these areas is increasing. Women tend to be more vulnerable than men to the effects of environmental degradation because they are often involved in harvesting common property resources, such as wood and water.

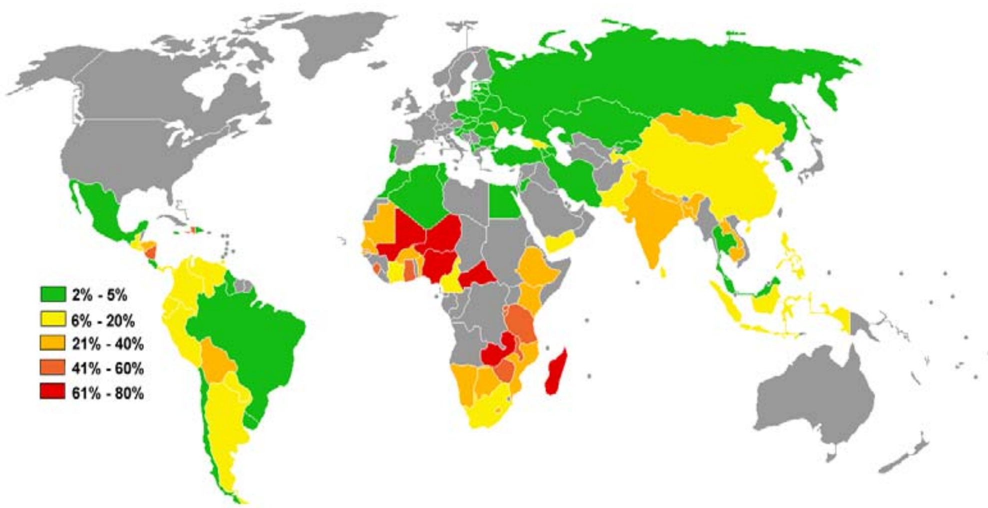


Figure 3. Percentage of population living on less than 1 dollar/day (Source: WRI, 2006).

3. Land Use and Ecosystem Services

Land plays a dual role in the environment: first, as a basis for agriculture in its widest sense, including livestock production, inland fisheries and forestry; and secondly, through the provision of ecosystem services, such as regulation of the hydrological cycle, carbon storage and sink, and support for biodiversity and habitats. Recent changes in land use are occurring on a larger scale than ever before, involving entire landscapes. Such large-scale changes through deforestation, expansion of agricultural land, and urban and suburban growth will likely dictate the physical condition and extent of terrestrial ecosystems in the next several decades. Progressive fragmentation of the world's remaining forest blocks, build-up in coastal areas, and the spread of cities, suburbs, and attendant roads and infrastructure over once-rural tracts will do much to degrade the habitat and watershed values of these areas (UNDP et al., 2000). The very scale of these landscape-level changes, as well as the increasing intensity of industrial and agricultural processes, are inducing changes to the global systems and cycles such as the atmosphere and the nitrogen cycle that underpin the functioning of ecosystems. These changes represent long-term environmental threats of a profound and far-reaching nature. Global warming from the build-up of greenhouse gases is the best known example, with the likely potential for large-scale disruption of natural ecosystems, agriculture, and human settlements due to changes in rainfall and temperature patterns and rising sea levels. Disruption of the global nitrogen cycle through extensive use of fertilizers, the burning of fossil fuels, and other activities also have the potential to change the structure and composition of terrestrial and aquatic ecosystems. Homogenisation and specialisation of land use and the extension of uniform land use patterns over large areas with little regard for the natural diversity of their soils, vegetation, topography, hydrology, micro-climates or specific socio-economic context has been an important factor for productivity increase but also one of the main causes of land and environmental degradation during the last decades. This growing uniformity is observed not only with the extension of monocultures and farm mechanization and that of ranching in frontier areas, but also in forest plantations, aquaculture development and in some human settlements. While there are obvious advantages that have been driving such trends, especially economies of scale and efficient technologies in terms of production, labour and cash returns, they are increasingly shown to have multiple hidden costs, in particular, from a long-term perspective. In addition to the critical and often irreversible losses of habitats and biological diversity which result, these uniform landscapes are particularly vulnerable to the destructive impacts of storms, floods, wildfires and are less resilient to pest and disease outbreaks. They may have detrimental effects on ecosystem services, in particular, the hydrological regime in the watershed (protective vegetative cover to reduce soil erosion, recharge of water resources and purification), soil nutrient recycling capacity and enhanced carbon sequestration and regulated greenhouse gas emissions (GHG). People living in these areas are more vulnerable to socio-economic crises since their employment opportunities, sources and levels of income and market outlets may be severely limited by the uniformity of activities on the land and the limited diversity that these provide.

4. Agriculture and Climate Change

Climatic changes are predicted to reduce the livelihood assets of poor people, alter the path and rate of national economic growth, and undermine regional food security due to evolutions in natural systems and impacts on infrastructure. These changes would increase the number of people at risk of experiencing extreme poverty and hunger. The main threats are related to food security (higher temperatures, frequency and intensity of droughts and floods, loss of agricultural lands), water security (changes in rainfall patterns, glacier retreat) and forest-based incomes (loss of forest resources, forest fires, GHG emissions due to forest degradation). The countries which are most vulnerable to climate change impacts also tend to be the poorest ones. In addition, they do not have the means (e.g. data, observations, methods, tools, technical and institutional infrastructure capacity-building) to deal with this new situation.

Climate change will have major impacts on agriculture from the displacement of agro-ecological zones (and thus areas' suitability to various crops); greater instability in seasonal weather patterns (and thus agriculture, including food supplies); rising sea levels; and, probably storm damage with important implications for both coastal fisheries and aquaculture. The displacement of agro-ecological zones has major implications for the maintenance of traditional crop varieties and livestock breeds and threatens the agricultural biodiversity. The seas are both the greatest absorbers and the greatest producers of biomass. Forests can be a stabiliser of land and water, but their reduction for conversion to agriculture also contributes to the pattern of climate change.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) on Climate Change Impacts, Adaptation and Vulnerability highlights observed changes in the natural and human environment as a result of climate change. They show that natural systems have been and will be further affected by climate change and temperature increases in particular. The natural system change includes changes in hydrological, terrestrial, biological, marine and freshwater systems. These changes have also impacted human systems, although specific impacts are hard to discern due to adaptation and non-climatic drivers. Some of the impacts include changes in agricultural and forestry management, impacts on human health and the reduced ability to undertake certain activities. Other observations that cannot be verified as trends yet include increased flooding risk due to glacial lake outbursts, warmer and drier conditions in parts of Africa, and sea-level rise impacting coastal development.

The social and economic costs of not responding to climate change are generally seen to be much higher than the costs of responding to climate change and taking immediate corrective action. There is a much better understanding today about the regional and continental impacts, although there remain uncertainties as to when, where and how climate change will affect specific countries. Changes in temperature and precipitation and an increase in extreme weather events are likely to change food production potential in many areas of the world, especially Africa and Asia. There is the potential to disrupt food distribution systems and their infrastructure and to change the purchasing power of, for example, the rural poor (IPCC, 2007).

FAO, in collaboration with the International Institute of Applied Systems Analysis (IIASA), has developed the Agro-Ecological Zones (AEZ) methodology, a worldwide spatial soil and climate suitability database. The AEZ approach has been used by IIASA to quantify regional impacts and geographical shifts in agricultural land and productivity potentials and the implications for food security resulting from climate change and variability (Fischer et al., 2002). The analysis indicates that, on average, industrialized countries could gain in production potential while developing countries may lose. Findings that show the potential impact of changing distribution of water availability for food and agricultural production and food security include:

- Global agricultural production potential is likely to increase with increases in global average temperature up to about 3°C, but above this it is very likely to decrease.
- Cold climates would benefit from higher temperatures, and new agricultural land may become available at high latitudes and high elevations.
- There is significant potential for expansion of suitable land and increased production potential for cereals only when considering the use of “new land” made available by the warming of these cold climates at high latitudes.
- At lower latitudes, especially the seasonally dry tropics, crop yield potential is likely to decrease for even small global temperature increases, which would increase the risk of hunger.

- Increased frequency of droughts and floods would affect local production negatively, especially in subsistence sectors at low latitudes and will have much more serious consequences for chronic and transitory food insecurity and for sustainable development than will shifts in the patterns of average temperature and precipitation.

As it is evident from Figure 4, there will be winners and losers in terms of agricultural production. The losers will most likely be those who are least responsible for greenhouse gas emissions and are most vulnerable. The geographical areas of anticipated losses are notably located in the tropics and in developing countries where the adaptation potential is limited. There is a strong demand to establish a global responsibility system, functioning mechanisms for compensation, including the Clean Development Mechanism (CDM), fair trade agreements that consider the impacts of climate change and production patterns, and payment for environmental services such as carbon sequestration. The post-Kyoto policy and financial mechanisms need to foresee a better role for land use planning and sustainable land management as well as a better balance between adaptation and mitigation and an emphasis on the role of agriculture both as a source of greenhouse gas emission as well as a sink.

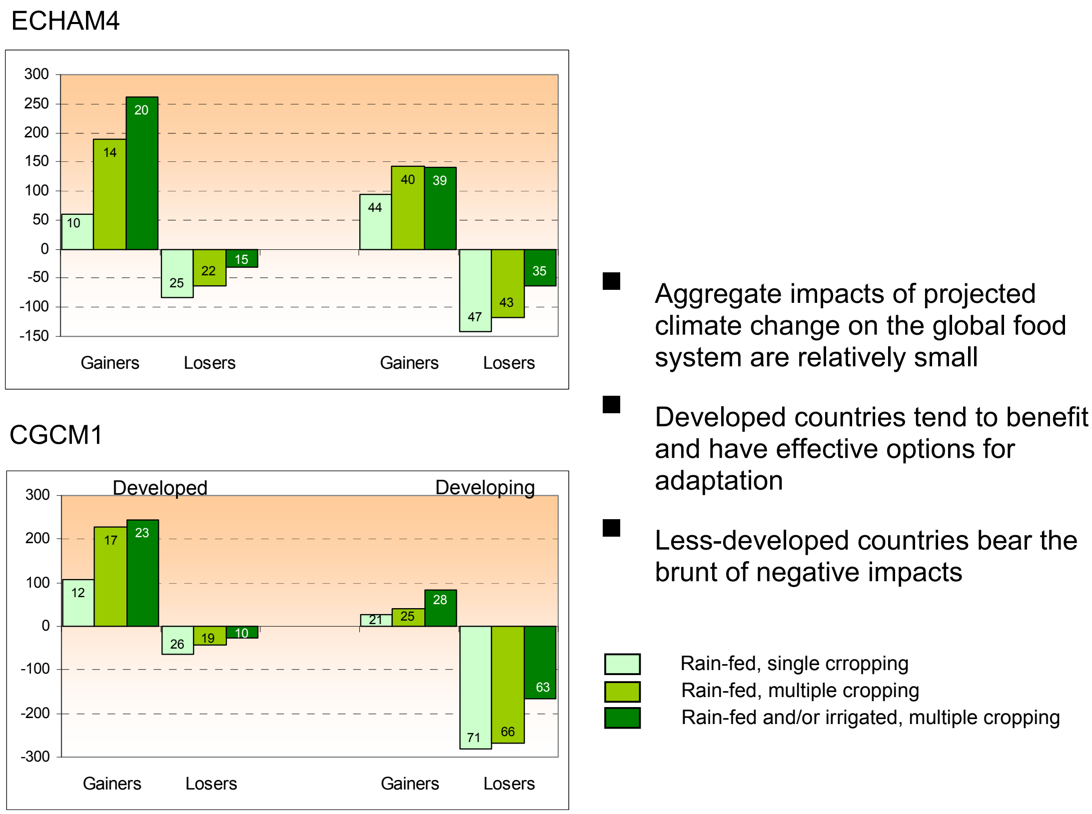


Figure 4. Impact of climate change on food production on currently cultivated land (millions of tonnes). Source: Fischer et al., 2002.

5. Agriculture, Externalities and Payment for Environmental Services

Most economic activities affect the environment either through the use of natural resources as an input or by using the 'clean' environment as a sink for pollution. The costs of using the environment in this way are called externalities. As they are the side effects of economic activity, they are external to markets, and so their costs are not part of the prices paid by producers or consumers. When such externalities are not included in prices, they distort the market by encouraging activities that are costly to society even if the private benefits are substantial. The types of externalities encountered in the agricultural sector have several features. Their costs are often neglected and often occur with a time lag.

In practice, there is little agreed data on the economic cost of agricultural externalities. This is partly because the costs are highly dispersed and affect many sectors of economies. It is also necessary to know the value of nature's goods and services, and what happens when these largely un-marketed goods are lost. As the current system of economic accounting grossly underestimates the current and future value of natural capital, this makes the task even more difficult (Costanza et al., 1997; Daily, 1997).

Significant needed increases in food output can only realistically be achieved by raising average yields or intensifying those areas already in production. But, there is increasing evidence that this may not be achievable using present conventional methods and without causing further damage, especially in intensively cultivated areas.

The future sustainability of agriculture depends also on young people wanting to remain on the land, and therefore farming must provide a way of life which is satisfying and which young people are unwilling to abandon in favour of the slums around and in cities.

Despite our best efforts to date, our conventional approaches increasingly seem to be inadequate for the task. The way to sustainable agriculture would seem to imply a change in the philosophy of agricultural production. Any conservation-effective system of agriculture (including pasture and forest management) should aim to reach, at least, the following goals:

- Significantly diminish run-off, and associated losses of soil, water, seeds, applied inputs, and organic matter;
- Increase efficiency of use of the available water and make more intensive production of biomass, even in steep areas and drylands;
- Enable a better environment for root development, including a better availability of plant nutrients in the root zone, better infiltration and water holding capacity of soils, reduce amplitude of day-to-night soil temperature ranges, etc.;
- Reduce farmers' costs of production and increase profit margins;
- Increase environmental and other services (socio-economic) and minimise negative externalities.

The challenge for future agriculture both in developing and developed countries is therefore to identify win-win options whereby intensification or changes in land use meet the demands of expanding population and economic development while reducing negative externalities of agricultural production and maintaining the goods and services provided by the environment. A desirable end-point for all viable land management and agricultural systems is clearly some design that enhances both the private benefits for resource users or resource managers and the public benefits through other functions and services of the nature. Scale is an important factor as the goals to increase food security, alleviate poverty and protect the environment go beyond individual land holdings to include overall human well-being and ecosystem management. Communities need to be involved in development decisions so as to mobilise collective willingness to balance production and protection and identify complementary scenarios of management options.

6. Investing in Land and Water for Food Security, Poverty Reduction and Ecosystem Services

One of the important reasons for environmental degradation is the perception that many of nature's services are free – no one owns them or is rewarded for them and farmers have little incentive to protect them. In addition, subsidies that encourage the production of marketed goods at the expense of other ecosystem services can aggravate their degradation. Current incentives tend to favour the production of food, fibre, and increasingly, biofuels, but they typically undervalue other beneficial services that farmers can provide, such as carbon storage, flood control, clean water provision or biodiversity conservation (FAO, 2007b).

The achievement of long-term food security, poverty alleviation and ecosystem services throughout the world will largely depend on the improvement of land use through the adoption of appropriate and sustainable land use systems and land management practices and technologies. Four interrelated paths are being considered by current food security strategies:

- Maintain high agricultural yields on productive lands while preventing further environmental decline;
- Increase agricultural productivity on medium and low potential lands;
- Increase purchasing power through greater non-farm rural and urban employment;
- Implement policies to support economic liberalization, which do not discriminate against agriculture.

As land resources for agriculture are finite and almost all suitable lands are already being exploited, such strategies call necessarily for:

- reversing present trends of land resources degradation and depletion of agricultural lands, and
- developing more efficient land use patterns and practices adapted to land productivity potentials and limitations and to the prevailing socio-economic and cultural context.

The above strategic path needs to be completed by a number of social and policy considerations that are also fundamental for sustainable development, economic growth and well-being of the planet Earth and its people. The role of land as an economic asset and the implication of access to assets in rural economy are confined to the discussion on physical assets – land and water – and financial means. Widely recognised (FAO, 2006b), these are assets which have a critical role towards the empowerment of the rural poor, basically for two reasons: first, they constitute the major source of income, savings and resilience of the poor; and second, they are effective instruments to enhance the leverage of the poor in local decision-making processes. Reduced land holding inequalities is the key to alleviating rural poverty and improving household food security. Appropriate land tenure and land use and property rights would also induce a greater incentive for investment on land. It would catalyse the practices of sustainable resource use and combating land degradation, thus contributing to the goal of Sustainable Agriculture and Rural Development (SARD). However, the correlation between access to land and reduced poverty is strong where the land quality is not poor or employment opportunities outside of the agricultural sector are not promising (FAO, 2006b).

To the above-mentioned qualification of the importance of land reform, the importance of water resources should be added. As the major part of developing countries is water stressed regions, secured access to water becomes a determinant equity factor. The Green Revolution considerably reduced rural poverty in Asia by boosting the productivity of irrigated bottomlands. In this context, the share of the incremental gains by the rural poor was determined mostly by the amount of water controlled by them than the surface area of their cropland. The International Fund for Agricultural Development (IFAD)

Rural Poverty Report of 2001 correctly *affirms that more access and control over water resources has to be ensured by the rural poor if more agricultural benefits are to be accrued to them*.

A sound knowledge of local land conditions, of the land potentials and constraints and of the related land use systems and land use practices and their variation in space and in time is now recognized as a vital basis for a more “down-to-earth” approach in the land use and food security analysis and planning process.

Land resource inventories, land use and land degradation surveys, land evaluation and land zoning tools, as well as socio-economic surveys that take into account customary laws, land tenure as well as gender and equity issues, and participatory appraisal and conflict resolution tools are all vital features of a comprehensive assessment and planning process for improved food and livelihood security. The development and implementation of effective plans requires multi-disciplinary expertise as well as information, improved technologies and technical and institutional support. Recognition and understanding that sustainable land management depends on the capacity of land users to effectively use, conserve and sustain their soil, water and biological resources is fundamental to improving both the productivity and conservation of resources. Above all, it requires willingness and commitment at all levels to bring about a change in the paradigm that favours long-term conservation and sustainability over and above short-term economic gain.

Conclusion

Land use is no longer a local issue but a force of global importance as the world's six billion people compete for food, water, fibre and shelter. Nearly one-third of the world's land surface is now in use for agriculture and millions of acres of natural ecosystems are converted each year. Many of the agricultural practices are unsustainable, requiring increasing external inputs to maintain the economic productivity of the land. While land use practices vary greatly across the world, their ultimate outcome is generally the same: the acquisition of natural resources for immediate human needs, often at the expense of degrading environmental conditions. Agriculture employs more people and uses more land and water than any other human activity. Ensuring appropriate incentives for these people is essential. Population growth, rapid economic development, increasing demand for biofuels and climate change are putting pressure on environmental resources already under pressure throughout the world while agriculture is expected to feed a world population that will increase from six to nine billion by 2050.

One of the important reasons for environmental degradation is the perception that many of nature’s services are free – no one owns them or is rewarded for them and farmers have little incentive to protect them. In addition, subsidies that encourage the production of marketed goods at the expense of other ecosystem services can aggravate their degradation. Current incentives tend to favour the production of food, fibre, and increasingly, biofuels, but they typically under-value other beneficial services that farmers can provide, such as carbon storage, flood control, clean water provision or biodiversity conservation.

Farmers can provide better environmental outcomes, but they need incentives to do so. Payments for environmental services represent one way of increasing incentives to adopt improved agricultural practices – and even to offset pollution generated in other sectors. Payments can take a variety of forms as voluntary transactions involving farmers, communities, taxpayers, consumers, corporations and governments. They could be direct payments by governments to producers or indirect transfers, such as consumers paying extra for a cup of shade-grown coffee beans. Hundreds of payment programmes for environmental services are currently being implemented around the world, mainly as part of forest conservation initiatives, but relatively few programmes for environmental services have targeted farmers and agricultural lands in developing countries. However, payments may also have adverse impacts on poverty and food security in some cases, should they result in a reduction in demand for agricultural employment or increases in food prices. If properly designed, payment programmes for environmental services might also benefit many of the more than one billion poor people in developing countries that live in fragile ecosystems. This requires careful targeting as well as measures to monitor delivery of environmental services.

References

Costanza, R., R. d’Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O’Neil, J. Parvelo, R.G. Raskin, P. Sutton and M. van den Belt, 1997. “The Value of the World’s Ecosystem Services and Natural Capital” in *Nature* 387, 253-260; also in *Ecol. Econ*. 25(1), 3-15.

Daily, G. (ed.), 1997. *Natures’ Services: Societal Dependence on Natural Ecosystems*. Island Press, Washington, D.C.

FAO, 2000. *Agriculture: Towards 2015/30*. Global Perspective Studies Unit, FAO, Rome.

FAO, IFAD and WFP, 2005. *General Assembly – 59th Session. High-Level Dialogue on Financing for Development, Meeting the Millennium Development Goals, Financing for Food Security, Agriculture and Rural Development.* New York, 27-28 June 2005.

FAO, 2006a. *The State of Food Insecurity in the World 2006*. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO, 2006b. The International Conference on Agrarian Reform and Rural Development (ICARRD), organized by FAO. Porto Alegre, Brazil, March 7 -10, 2006.

FAO, 2007a. *The State of Food and Agriculture.* Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO, 2007b. *Climate Change and Food Security*. FAO Inter-departmental Working Group on Climate Change. Food and Agriculture Organization of the United Nations, Rome, Italy.

Fischer, G., M. Shah, and H. van Velthuizen, 2002. *Climate Change and Agricultural Vulnerability*. IIASA, Laxenburg, Austria.

IPCC, 2007. *Fourth Assessment Report Summary for Policy-makers*. Intergovernmental Panel on Climate Change, Geneva. Switzerland.

Pimentel and Wilson, 2005. "World Population, Agriculture, and Malnutrition" in *World Watch Magazine*, January. World Watch Institute, USA.

World Development Report, 2007. Available at: www.worldbank.org/wdr2007.

UNDP, UNEP, World Bank and WRI, 2000. *A Guide to World Resources 2000-2001: People and Ecosystems: The Fraying Web of Life*. World Resources Institute, Washington, DC, USA.

World Resources Institute, 2006. Available at http://earthtrends.wri.org and
http://commons.wikimedia.org/wiki/File:800px-Percentage_population_living_on_less_than_1_dollar_day.png.

Poverty at the Nexus of the Global Water Crisis and Desertification[1]

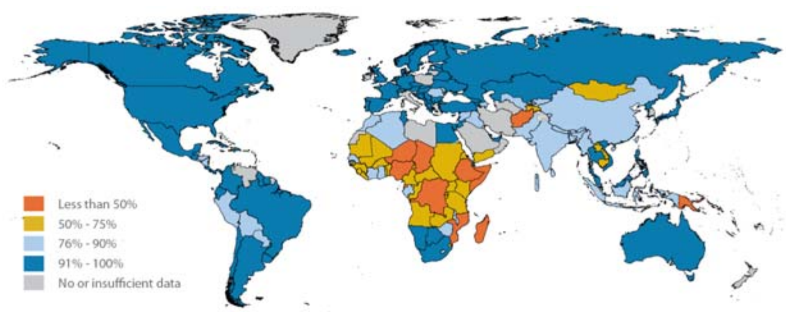
Zafar Adeel, UNU-INWEH

Introduction

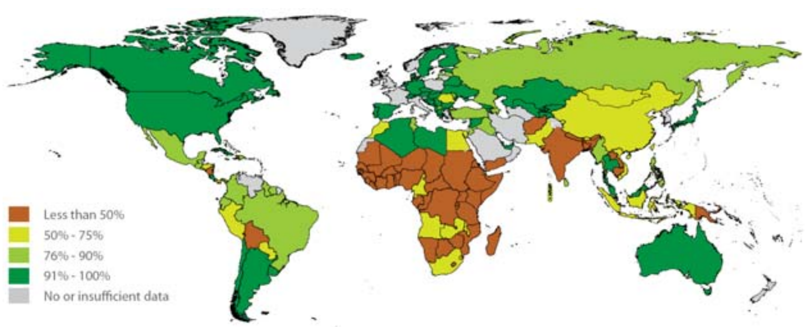
We are in the midst of a global water crisis – which can be defined in human terms as a crisis in which about 1 billion people are without access to safe drinking water (JMP, 2008) (please see Box 1 for further information). At the same time, a vast majority of people living in drylands worldwide are facing the threat of desertification (please see Box 2 for a definition of desertification), which is deemed as the most threatening environmental challenge of our times (UNU, 2007). The global population of dryland dwellers is ca. 2 billion, almost all of whom live in developing countries facing severe water stress.

Box 1. The Global Water Crisis.

Lack of access to safe water and adequate sanitation is one of the most important threats to human well-being worldwide. Globally, almost 1 billion people lack access to safe water supplies and 2.5 billion people live without access to improved sanitation, the vast majority of whom live in rural areas (JMP, 2008). In 2002, the total number of deaths attributed to poor water, sanitation and hygiene was over 3.5 million (Prüss-Üstün et al., 2008). An estimated 4 billion cases of diarrhoeal diseases occur every year – most of which are preventable through improved hygiene.



Availability of improved (safe) drinking water in 2006 (source: JMP, 2008).



Access to adequate sanitation in 2006 (source: JMP, 2008).

Box 2. Desertification.

Desertification – land degradation in drylands – is one of the greatest global challenges of our times, and correlates directly to poverty, food insecurity and degradation of human well-being. Desertification directly results in biodiversity changes and a decline in soil fertility, water availability and plant cover, which indirectly affect the livelihoods of dryland populations. Conservative figures estimate the extent of desertified area ranging from 10-20% of all drylands (Adeel et al., 2005), while a much larger area remains at risk. Measurement of a persistent reduction in the capacity of ecosystems to supply services provides a robust and operational way to quantify land degradation and thus, desertification. Such a quantification approach is robust because these services can be monitored, some of which are already being monitored routinely.

This paper argues that people impacted by desertification are living in water-scarce environments and chronically suffer from lack of access to safe drinking water. So, while the global water crisis and desertification trends are treated as two distinct

[1]This paper is based on the presentation “Land Degradation and Sustainable Management of Water Resources” given by the author on 1 September 2007 at the International Forum on Soils, Society & Global Change.

processes, they impinge in combination on the lives of the same people in developing countries. As a result, the human well-being of these populations is severely impacted. Their vulnerability and poverty are linked to health impacts caused by the lack of access to safe drinking water and by food insecurity and malnutrition caused by degradation of ecosystem services due to desertification.

1. Drivers of Desertification

Desertification is an outcome of the unsustainable management of natural resources in dryland ecosystems. Many extraneous drivers – like population pressure, changing climate patterns and globalization – force land users to adopt inadequate or inappropriate management approaches. Some forces of globalization, while striving to reduce economic inequality and eliminate poverty, contribute to worsening desertification; one common example are perverse agricultural subsidies. These effects are often exacerbated due to the lack of adequate knowledge and sound scientific information amongst the land users and natural resource managers. In many cases, most particularly in drylands, approaches for management of natural resources often fail to account for longer-term changes in water availability and quality, both in terms of absolute quantities and per capita distribution.

Desertification is a process that can often destabilize societies by deepening poverty and reversing the gains otherwise achieved through international and national development activities. The impacts of desertification are further exacerbated by political marginalization of the dryland poor, by the slow growth of health and education infrastructure and by the lack of livelihood alternatives to resource depleting agricultural practices.

The impacts of desertification are not isolated to drylands but are truly global in nature. For example, dust storms which typically originate in the Sahara and Gobi deserts, affect the entire Northern hemisphere. Movement of people from dryland areas to non-dryland areas is also significant: some experts estimate that the number of people at risk of displacement due to severe desertification will exceed 50 million over the next ten years. It is also becoming increasingly accepted by the international community that our inability to address desertification is underpinned by a failure to formulate effective policies.

2. Societal Impacts of Converging Crises

The impacts of these two converging crises on dryland societies around the world are quite stark. On a global scale, these impacts are quite pronounced when measured as key human well-being indicators, as shown in Figure 1 (Millennium Ecosystem Assessment, 2005). Infant mortality in drylands in developing countries averages about 54 children per 1,000 live births, ten times higher than that in developed countries. Income per capita and statistics for nutrient-deficient children's populations also show similar disparities.

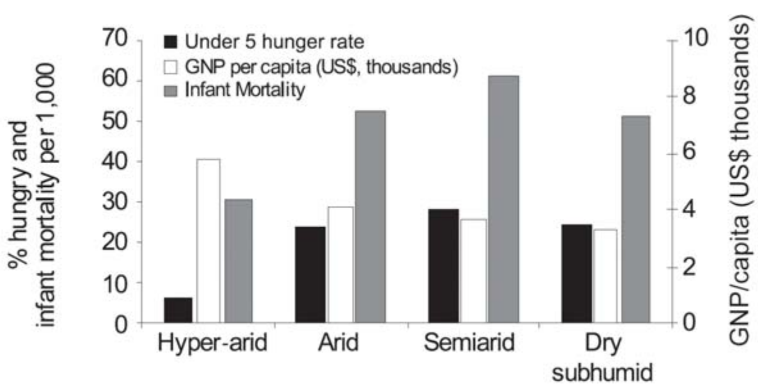


Figure 1. Human well-being indicators in dryland countries (source: Safriel and Adeel, 2005).

These trends are also quite prominent when observed at national and local levels. One may argue that averaging at the global level may, in fact, mask some rather drastic situations. To illustrate this point, this paper presents the case of six dryland countries: Bolivia, Chad, Mali, Mongolia, Niger and Sudan. These countries were selected for this analysis because: (i) the entire country falls within the drylands envelope, with the range in levels of aridity presented in Table 1; (ii) the provisioning of the basic water and sanitation facilities is rather poor, as presented in Table 2; (iii) these countries are considered to fall within the envelope of least developed countries; and (iv) comparable human well-being indicators are available. Some regional distribution is also represented for Asia, sub-Saharan Africa and South America, although human well-being and development indicators vary quite considerably in each of these regions.

Table 1. Human well-being indicators in selected dryland countries (sorted by decreasing GDP level).

Country	Aridity Level	Income GDP (US$ PPP*)/capita	Population below poverty %	Infant mortality rates /1,000 live births
Bolivia	Hyper arid – Dry sub-humid	$2,619	62.7	52
Mongolia	Hyper arid – Semi-arid	$2,107	36.1	39
Sudan	Hyper arid – Dry sub-humid	$2,083	-	62
Chad	Hyper arid – Dry sub-humid	$1,427	64.0	124
Mali	Hyper arid – Dry sub-humid	$1,033	63.8	120
Niger	Hyper arid – Semi-arid	$ 781	63.0	150
High Income OECD		**$33,831**	**0**	**5**
Year of data	2000	2005	latest in 1990-2004 period	2005
Source:	*Millennium Ecosystem Assessment, 2005*	*UNDP, 2007*	*UNDP, 2007*	*UNDP, 2007*

*PPP: Purchasing Power Parity

Table 2. Access to improved water supply and adequate sanitation in selected dryland countries (sorted by water availability).

Country	Water Availability 1,000 m^3/capita	Access to Water %	Access to Sanitation %
Bolivia	69.4	86	43
Mongolia	13.2	72	50
Sudan	1.9	70	35
Mali	7.5	60	45
Chad	4.9	48	9
Niger	2.7	42	7
High Income OECD	**-**	**99**	**99**
Year of data	2005	2006	2006
Source:	*UNESCO, 2006*	*JMP, 2008*	*JMP, 2008*

Three key human well-being indicators used in this comparison are income per capita (nominally presented as GDP US$ per capita in terms of Purchasing Power Parity), the fraction of the national population living below poverty levels (shown as percentage of national population), and infant mortality rates (presented as number of deaths per live births).

When the statistics of Tables 1 and 2 are juxtaposed, two facts are apparent. First, the countries with the worst values for the economic and well-being indicators (Niger, Chad and Mali) are also the ones with the worst coverage for water and sanitation availability. Many recent studies claim that these two sets of variables are not independent of each other and that mutual feedback mechanisms exist (Schuster-Wallace, 2008). A lack of available financial resources, and often a misguided sense of national priorities, leads to inadequate national investments in the most fundamental infrastructure needed for water and sanitation. This is further compounded by the inadequate investment in the public health sector which, in turn, is burdened by a disproportionately high number of health cases (when compared to OECD (Organisation for Economic Co-operation and Development) countries) stemming from water- and sanitation-related problems.

The national-scale policy failures are also worsened by a comparable lack of international awareness of the interconnectivity of these developmental and environmental issues, particularly amongst those responsible for designing and implementing development aid policies. Very few development and aid policies recognize desertification or access to water and sanitation as the top-most investment priority; most often, governance, gender equity and "economic development" (often defined as industrial and/or agricultural growth) are considered the top development priorities.

Second, the differences in economic and well-being indicators for the case study countries and developed countries (represented here as "high income OECD" countries) are stark and differ by orders of magnitude. Most notably, Mali and Chad have average income levels that are almost two orders of magnitude lower than those in developed countries. This translates to a lack of financial wherewithal to meet the national challenges. A majority of the population in these six countries lives below the poverty level. As an indirect but related consequence, the infant mortality rates in some cases are more than 30 times higher than those found in the developed countries.

While more work remains to be done to establish a well-defined statistical correlation between these key indicators, the pattern of abject poverty connected to desertification and the water crisis is repeated in numerous developing countries.

3. Recommendations for Ensuring Sustainability

The projection of future trends in water availability points to increasing challenges. The most recent estimates developed by the Intergovernmental Panel on Climate Change (IPCC, 2007) indicate that most of the drylands in Africa and Asia will continue to become drier, with less water available as a result of shifting precipitation patterns. This means that an even greater emphasis must be placed on improved water management with a view to overcome land degradation.

The following steps are necessary to ensure integration between land and water use:

First, assessment and valuation of all water resources, including groundwater, should be conducted at the watershed or landscape scale. Any development or management schemes must account for availability and sustainability of water in a manner that takes into account the global patterns of climate change.

Second, assessment of land use patterns should also be undertaken on the watershed or landscape scale, providing estimates for future water uptake. Use of mathematical models that account for down-scaled climate models and local land use patterns is critical to arriving at relevant outputs. Such outputs must include tools for early detection of possible crisis points, which should be directly linked into policy formulation processes.

Third, we must better delineate the broader management approaches for optimal water use and possible shifts in livelihood approaches (Adeel et al., 2008; Adeel and Safriel, 2008). Such a societal engineering requires the development of a stakeholder dialogue that brings together local communities and their leaders. This approach must also explicitly include the provision of safe drinking water and sanitation, which are frequently isolated from the discussion on integrated land or water management.

References

Adeel, Z., C. King, T. Schaaf, R. Thomas and B. Schuster, 2008. *People in Marginal Drylands: Managing Natural Resources to Improve Human Well-being, A policy brief based on the Sustainable Management of Marginal Drylands (SUMAMAD) project*. United Nations University International Network on Water, Environment and Health (UNU-INWEH), Canada.

Adeel, Z. and U. Safriel, 2008. “Achieving Sustainability by Introducing Alternative Livelihoods” in *Sustainability Science* 3(1): 125-133.

IPCC, 2007. *Climate Change 2007: Synthesis Report*, An Assessment of the Intergovernmental Panel on Climate Change (IPCC), Valencia, Spain.

JMP, 2008. *Progress on Drinking Water and Sanitation: Special Focus on Sanitation*. World Health Organization and United Nations Children’s Fund - Joint Monitoring Programme (JMP), UNICEF, New York and WHO, Geneva.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Desertification Synthesis*. World Resources Institute, Washington, D.C.

Prüss-Üstün A., R. Bos, F. Gore and J. Bartram, 2008. *Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health*. World Health Organization, Geneva.

Safriel, U. and Z. Adeel, 2005. “Dryland Systems” in *Ecosystems and Human Well-being: Current State and Trends. Volume 1*: Millennium Ecosystem Assessment. Island Press, Washington D.C.

Schuster-Wallace, C.J., V. I. Grover, Z. Adeel, U. Confalonieri and S. Elliott, 2008. *Safe Water as the Key to Global Health*. United Nations University - International Network on Water, Environment and Health (UNU-INWEH), Canada.

UNDP, 2007. *Human Development Report 2007/2008 – “Fighting Climate Change: Human Solidarity in a Divided World”*. United Nations Development Programme, New York.

UNESCO, 2006. *Water: A Shared Responsibility. The United Nations World Water Development Report 2.* United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris.

UNU, 2007. *Overcoming One of the Greatest Environmental Challenges of our Times: Rethinking Policies to Cope with Desertification. A policy brief based on the Joint International Conference: “Desertification and the International Policy Imperative” Algiers, Algeria, 17-19 December 2006*. United Nations University - International Network on Water, Environment and Health (UNU-INWEH), Canada.

The Role of Ecological Restoration and Sustainable Land Management for Biodiversity

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Introduction

Biodiversity is the foundation of ecosystem services that contribute to human well-being and is therefore important for both human-managed and natural ecosystems. On a global scale, there have been more rapid changes in biodiversity in the past 50 years than at any time in human history (Millennium Ecosystem Assessment, 2005). The aim of this paper is to elucidate the effects of land degradation and ecological restoration on biodiversity and ecological services of damaged ecosystems.

The concept of biodiversity means different things to different people, which can result in misunderstanding (Mayer, 2006). The issue of biodiversity is based on a concern about depletion of biological resources at multiple levels of organization (Noss, 1990) and it involves more than just the diversity of species and their endangerment or extinction. The commonly used definition of biodiversity is "the variety and variability among living organisms and the ecological complexes in which they occur" (Millennium Ecosystem Assessment, 2005). In that sense, species or genetic composition is only one attribute of biodiversity. Other important attributes are: ecosystem functions, which include the processes that are crucial for maintenance of biodiversity such as water and nutrient cycles, interspecific interactions and demographic processes; in addition to structural attributes such as physiognomy, landscape patterns and population structure (Noss, 1990; Rogers and Montalvo, 2004). Thus, it is important to specify which attributes of biodiversity are presented or discussed in each case.

Loss of biodiversity has been defined as "the long-term or permanent qualitative or quantitative reduction in components of biodiversity and their potential to provide goods and services, to be measured at global, regional and national levels" (CBD, 2004). According to this definition, biodiversity is not only lost through the extinction of species or alleles, but also through diminished potential to provide a particular service and the homogenization of biodiversity on a global scale due to introduction of species into new ranges (Millennium Ecosystem Assessment, 2005).

1. Land Degradation and Biodiversity

Land degradation generally results in the decline of biodiversity on various levels. At the regional and landscape level, land degradation is often associated with changes in landscape units, e.g. deforestation and an increase in areas with sparse or no vegetation. An example of a large-scale change in landscape units is the massive deforestation of Iceland. It has been estimated that up to 96% of the native birch woodlands that covered the country at the time of settlement in the 9th century had disappeared by the beginning of the 20th century (see review by Aradóttir and Eysteinsson, 2005). This was caused by extensive clearing, burning, and cutting for fuel, which rapidly reduced the woodland area after the settlement, in addition to the unsustainable grazing by domestic herbivores, which exaggerated the problem and inhibited regeneration of the birch (Arnalds, 1987). The woodland deterioration probably contributed to accelerated soil erosion after settlement due to increased susceptibility to erosional processes with increased cryoturbation and solifluction and higher wind speeds on the soil surface (Aradóttir and Arnalds, 2001), and more surface run-off because of slower infiltration (Orradóttir, 2002) in open landscapes compared to woodlands.

Another example shows that the rate of landscape conversion can be quite high. Remotely-sensed land cover and topographic data from two regions in the Bolivian Andes was used to compare land cover over a 20-year period (Brandt and Townsend, 2006). Both regions experienced extensive deforestation, desertification and agricultural expansion over this period, affecting 17% of one and 7% of the other. Furthermore, spectral mixture analysis indicated the occurrence of rangeland degradation with increases in soil and non-photosynthetic vegetation fractions (Brandt and Townsend, 2006).

Deforestation and conversion of vegetated land to bare ground not only represents a loss of regional biodiversity, but also have potentially serious effects on ecosystem functions, plant and animal communities, and biodiversity at lower levels. In the valley of Little Karoo in South Africa, overgrazing and trampling have resulted in severely degraded areas with diminished cover of perennial vegetation and biological soil crust (reviewed by Le Maitre et al., 2007). This degradation has disrupted landscape linkages such as hydrological flows and the recycling of organic matter and nutrients, thus severely reducing future land use options.

The above examples show that land degradation can reduce important ecological capital at the ecosystem level. One of these is soil organic matter, a key component of soil quality, which is severely reduced by land use conversion and degradation (Lal, 2004). Coming back to the Icelandic example, it has been estimated that between 120 and 500 million tonnes of organic carbon have been lost from Icelandic soils during eleven centuries of human settlement, approximately half of which have been oxidized and lost to the atmosphere (Óskarsson et al., 2004). Water is another ecological capital affected by land degradation. A number of studies have shown that water infiltration is related to vegetation cover and the type of vegetation (e.g., Thurow et al., 1986; Hester et al., 1997; Descheemaeker et al., 2006) and can be adversely affected by heavy grazing and other management practices that reduce organic ground cover (Thurow et al., 1988; Wilcox and Wood, 1988; Flenniken et al., 2001). Land degradation can also affect river function and biodiversity away from the degraded area through increased sedimentation (e.g. Cowley, 2006). Long-term vegetation productivity is also reduced by overgrazing and land degradation (e.g. Fynn & O'Connor, 2000; Li et al., 2004a; Wessels et al., 2007). Changes in ecosystem functioning brought on by land use conversion and soil degradation are often associated with habitat fragmentation or loss and disruption of community structure (Novacek and Cleland, 2001). Furthermore, habitat fragmentation may lead to loss of genetic diversity and isolation of populations that can result in genetic drift (Falk et al., 2006).

Whisenant (1999) introduced a conceptual model of the interactive dynamics involved in soil degradation, characterizing them as a downward spiral. In his model, a prolonged loss of vegetation cover, e.g. due to overgrazing, deforestation or cultivation, will lead to reduced availability of soil-water for plant growth and therefore decreased plant production. Decreased organic inputs into soils will negatively affect soil organic matter and biotic activity in the soil, thus resulting in reduced soil fertility and deterioration of soil structure. Thus, both nutrient and water-holding capacity of soils is reduced, which can lead to soil erosion, decreased plant production, etc. (Whisenant, 1999; King et al., 2006).

One of the consequences of biodiversity loss and ecological services associated with land degradation and desertification is a reduced ability of ecosystems to store and sequester carbon in soils and vegetation, as discussed above. Reduced carbon reserves and increased CO_2 emissions contribute to greenhouse gases in the atmosphere and consequently to global climate change, which may in turn intensify land degradation and biodiversity loss (Duraiappah and Naeem, 2005). Accordingly, there are important linkages between the UN Conventions on Climate Change (UNFCCC), Biological Diversity (CBD) and Combating Desertification (UNCCD).

2. Restoration of Degraded Areas

Sustainable land management that preserves ecosystem functions and healthy soils has an important role in conserving biodiversity and preventing the formation of degradation spirals. However, the alleviation of non-sustainable land use is not always sufficient to reverse the degradation of severely degraded land, and interventions are needed in order to restore necessary structure and function and improve future options for land use (Hobbs and Norton, 1996).

Ecological restoration has been defined as ‘‘the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed’’ (SER, 2004). The role of ecological restoration in reversing the effects of land degradation is expected to be increasingly important as more ecosystems become degraded and as demands for their services continue to grow (Millennium Ecosystem Assessment, 2005; Duraiappah and Naeem, 2005; Palmer et al., 2004). In this context, it is important to assess the effects of ecological restoration on different aspects of biodiversity and ecosystem services.

Approaches to ecological restoration depend on many factors, including the stage of degradation, goals of the particular restoration project, available resources, and other socio-economic and environmental factors. Areas that are more or less fully functional and have not been severely disturbed may only need improved management to achieve desired restoration goals, while areas that have crossed transition thresholds (cf. Hobbs and Norton, 1996; Whisenant, 1999) need more manipulations. A current paradigm of ecological restoration assumes that abiotic and biotic thresholds may exist, which prevent the recovery of ecosystems from a degraded stage without management inputs (Hobbs and Norton, 1996; Whisenant, 1999).Where the transition thresholds are primarily biotic, the recovery requires mainly vegetation manipulation, such as the introduction of some key species. If, on the other hand, the degraded ecosystems have crossed abiotic thresholds where primary processes are not functional, more drastic modification of the physical and chemical environment may be needed in order to restore function (Hobbs and Harris, 2001). In the following examples, the effects of different restoration manipulations on ecosystem recovery, biodiversity and ecological services will be examined.

In the Tenger desert in China, a simple community of sand-binding species was established on a barren dune environment, resulting in stabilization of the soil surface (Li et al., 2004b). In time, this intervention also led to improved soil structure, organic matter, nutrients and water content, facilitation of vegetation succession and colonization of insects and birds (Li et al., 2004b). Thus, the establishment of a relatively simple community increased biodiversity and transformed the barren sand-dunes into an ecosystem with complex composition, structure and function.

In southern Iceland the addition of organic mulch (sheep manure) and mineral fertilizer led to the formation of vegetation cover on an eroded area within a few years, and stimulated the formation of biological soil crusts and the colonization of many native species (Elmarsdóttir et al., 2003). This was accompanied by an increased value of the area for sheep grazing and accumulation of carbon stocks in soil and vegetation, indicating a potential for carbon sequestration (Aradóttir et al., 2000). Thus, a simple reclamation effort has led to restoration of important ecological functions and facilitated vegetation succession. Experiments from the same region, following ecological succession after different reclamation treatments over time, show that manipulations that involve seeding of different grass species and mineral fertilization can stabilize the soil surface and form a good vegatation cover within a few years (Aradóttir et al., 2005). This is associated with an increase in water infiltration, OC and N levels (Orradóttir and Arnalds, 2007). Studies of longer-term (20-45 years) effects of reclamation in the same area indicate that seeding of grasses and fertilization can facilitate a successional trajectory towards native woodland or heathland but vegetation cover of untreated areas remains sparse, despite protection from grazing for several decades (Gretarsdóttir et al., 2004). These studies demonstrate the importance of simple reclamation manipulations in moving these degraded ecosystems over abiotic thresholds and thus reversing degradation spirals (cf. Whisenant, 1999). Other studies have also revealed that reclamation manipulations of eroded areas can enhance biodiversity on many levels, for example, by facilitating colonization of key species (e.g., Aradóttir and Arnalds, 2001), microfauna (e.g. Aradóttir and Halldórsson, 2004) and biological activity of soils (Oddsdóttir, 2002; Sigurðardóttir, 2004). Ecosystem services, such as carbon sequestration (Aradóttir et al., 2000; Arnalds et al., 2002) and increased recreation opportunities (Pétursdóttir, 2007) are also valuable derivatives of ecological restoration.

The outcome of reclamation manipulations varies greatly depending on the treatment (e.g. Newman and Redente, 2001; Grétarsdóttir et al., 2004). Various aspects of biodiversity and ecological services can be negatively affected by reclamation interventions that result in the dominance of exotic species or conditions that impede the colonization of native species (Densmore, 1992; Forbes and McKendrick, 2002; Magnússon et al., 2004; Pétursdóttir 2007). Furthermore, exotic species used for revegetation can invade native habitats and alter plant communities and ecosystem processes far beyond the areas where they were originally used (e.g., Pickart et al., 1998; Whisenant, 1999; Williamson and Harrison, 2002; Magnússon et al., 2004). This may lead to global homogenization, which represents further losses in biodiversity (Olden et al., 2004; Millennium Ecosystem Assessment, 2005) and creation of 'novel' ecosystems which may be difficult and very costly to return to a more 'natural' stage (Hobbs et al., 2006). Thus, it is very important to select species for restoration programmes, not only with regards to their short-term value for restoring ecosystem structure and function, but also with regards to their long-term effects on community composition and ecosystem dynamics.

Conclusions

Land degradation results in structural, functional and compositional decline of biodiversity at various levels. Furthermore, the loss of biodiversity associated with land degradation generally results in reduced carbon storage and increased CO_2 emissions, thus contributing to global climate change. Examples from different areas of the world show, however, that it is possible to restore many aspects of biodiversity, even under very unfavourable conditions. This includes important ecosystem services such as carbon sequestration, demonstrating the possibility to achieve important synergies in working towards the goals of the UN Conventions on Climate Change (UNFCCC), Biological Diversity (CBD) and Desertification (UNCCD).

Ecological restoration will become increasingly important as more ecosystems become degraded and demands for their services grow. The outcome of restoration programmes, however, depends on their context and the methods used. Restoration strategies that support key species of native communities will enhance biodiversity on most levels, while strategies that lead to increase of exotic or weedy plant species and monocultures can reduce important aspects of biodiversity, although they may increase some functional aspects in the short term. Emphasizing a single restoration goal, such as carbon sequestration, entails the risk that restoration methods and species are selected only on the basis of potential sequestration rates. This may result in the loss of biodiversity if it entails the use of exotic species or other methods that impede the colonization and growth of native species. Therefore, it is important to design restoration programmes with multiple goals in mind, including restoration of native biodiversity, increased resource retention, reduced soil erosion, carbon sequestration and other attributes in harmony with the needs and wishes of the local communities.

References

Aradóttir, Á. L., and G. Halldórsson. 2004. ["Ecological Restoration of Degraded Areas"] in *Fræðaþing landbúnaðarins* 1: 86-93 (in Icelandic).

Aradóttir, Á. L., and Ó. Arnalds, 2001. "Ecosystem Degradation and Restoration of Birch Woodlands in Iceland" in F. E. Wielgolaski (ed.), *Nordic Mountain Birch Ecosystems*. UNESCO, Paris, and Parthenon Publishing, Carnforth, pp. 295-308.

Aradóttir, Á. L., and T. Eysteinsson, 2005. "Restoration of Birch Woodlands in Iceland" in J. A. Stanturf and P. Madsen (eds.), *Restoration of Boreal and Temperate Forests*. CRC Press, Boca Raton, pp. 195-209.

Aradóttir, Á.L., G. Halldórsson and Ó. Arnalds, 2005. "Landbót" [The outdoor restoration laboratory] in *Fræðaþing landbúnaðarins* 2: 279-282 (in Icelandic).

Aradóttir, Á. L., K. Svavarsdóttir, T. H. Jónsson and G. Guðbergsson, 2000. "Carbon Accumulation in Vegetation and Soils by Reclamation of Degraded Areas" in *Icelandic Agricultural Sciences*, 13, pp. 99-113.

Arnalds, A. 1987. "Ecosystem Disturbance in Iceland" in *Arctic and Alpine Research*, 19, pp. 508-513.

Arnalds, Ó., Á.L. Aradóttir and G. Guðbergsson, 2002. "Organic Carbon Sequestration by Restoration of Severely Degraded Areas in Iceland" in J. M. Kimble, R. Lal, and R. F. Follet (eds.), *Agricultural Practices and Policies for Carbon Sequestration in Soil*. CRC Press LLC, Boca Raton, pp. 267-280.

Brandt, J.S. and P.A. Townsend, 2006. "Land Use - Land Cover Conversion, Regeneration and Degradation in the High Elevation Bolivian Andes" in *Landscape Ecology*, 21, pp. 607-623.

CBD, 2004. *Decisions Adopted by the Conference of the Parties to the Convention on Biological Diversity at its Seventh Meeting – CBD COP7/30*. Available at: http://www.cbd.int/decisions/default.shtml?m=cop-07; retrieved 28 Aug. 2007.

Cowley, D.E., 2006. "Strategies for Ecological Restoration of the Middle Rio Grande in New Mexico and Recovery of the Endangered Rio Grande Silvery Minnow" in *Reviews in Fisheries Science*, 14, pp. 169-186.

Densmore, R. V., 1992. "Succession on an Alaskan Tundra Disturbance With and Without Assisted Revegetation with Grass" in *Arctic and Alpine Research*, 24, pp. 238-243.

Descheemaeker, K., J. Nyssen, J. Poesen, D. Raes, M. Haile, B. Muys and S. Deckers, 2006. "Run-off on Slopes with Restoring Vegetation: A Case Study from the Tigray Highlands, Ethiopia" in *Journal of Hydrology*, 331, pp. 219-241.

Duraiappah, A.K. and S. Naeem, 2005. “Ecosystems and Human Well-being: Biodiversity Synthesis” in *Millennium Ecosystem Assessment*. World Resources Institute, Washington, D.C.

Elmarsdottir, A., A.L. Aradóttir and M.J. Trlica, 2003. “Micro-site Availability and Establishment of Native Species on Degraded and Reclaimed Sites” in *Journal of Applied Ecology*, 40, pp. 815-823.

Falk, D.A., C.M. Richards, A.M. Montalvo and E.E. Knapp, 2006. “Population and Ecological Genetics in Restoration Ecology” in D.A. Falk, M.A. Palmer, and J.B. Zedler (eds.), *Foundations of Restoration Ecology*. Island Press, Washington D.C, pp. 14-41.

Flenniken, M., R.R. McEldowney, W.C. Leininger, G.W. Frasier, and M.J. Trlica, 2001. “Hydrologic Responses of a Montane Riparian Ecosystem Following Cattle Use” in *Journal of Range Management*, 54, pp. 567-574.

Forbes, B.C. and J. McKendrick, 2002. “Polar Tundra” in M.R. Perrow and A.J. Davy (eds.), *Handbook of Ecological Restoration. Volume 2. Restoration in Practice*. Cambridge University Press, Cambridge, pp. 355-375.

Fynn, R.W.S. and T.G. O'Connor, 2000. “Effect of Stocking Rate and Rainfall on Rangeland Dynamics and Cattle Performance in a Semi-arid Savannah, South Africa” in *Journal of Applied Ecology*, 37, pp.491-507.

Grétarsdóttir, J., Á.L. Aradóttir, V. Vandvik, E. Heegaard and H.J.B. Birks, 2004. “Long-term Effects of Reclamation Treatments on Plant Succession in Iceland” in *Restoration Ecology*, 12, pp. 268-278.

Hester, J.W., T.L. Thurow and C.A. Taylor, 1997. “Hydrologic Characteristics of Vegetation Types as Affected by Prescribed Burning” in *Journal of Range Management*, 50, pp. 199-204.

Hobbs, R. J. and D.A. Norton, 1996. “Towards a Conceptual Framework for Restoration Ecology” in *Restoration Ecology*, 4, pp. 93-110.

Hobbs, R.J. and J.A. Harris, 2001. “Restoration Ecology: Repairing the Earth's Ecosystems in the New Millennium” in *Restoration Ecology*, 9, pp. 239-246.

Hobbs, R.J., S. Arico, J. Aronson, et al., 2006. “Novel Ecosystems: Theoretical and Management Aspects of the New Ecological World Order” in *Global Ecology and Biogeography*, 15, pp. 1-7.

King, E.G. and R.J. Hobbs, 2006. “Identifying Linkages Among Conceptual Models of Ecosystem Degradation and Restoration: Towards an Integrative Framework” in *Restoration Ecology*, 14, pp. 369-378.

Lal, R. 2004. “Soil Carbon Sequestration Impacts on Global Climate Change and Food Security” in *Science*, 304, pp. 1623-1627.

Le Maitre, D.C., S.J. Milton, C. Jarmain, C.A. Colvin, I. Saayman and J.H.J. Vlok, 2007. “Linking Ecosystem Services and Water Resources: Landscape-scale Hydrology of the Little Karoo” in *Frontiers in Ecology and the Environment*, 5, pp. 261-270.

Li, J., J. Lewis, J. Rowland, G. Tappan and L.L. Tieszen, 2004a. “Evaluation of Land Performance in Senegal Using Multi-temporal NDVI and Rainfall Series” in *Journal of Arid Environments* 59, pp. 463-480.

Li, X.R., H.L. Xiao, J.G. Zhang and X.P. Wang, 2004b. “Long-term Ecosystem Effects of Sand-binding Vegetation in the Tengger Desert, Northern China” in *Restoration Ecology*, 12, pp. 376-390.

Magnússon, B., S.H. Magnússon and B.D. Sigurðsson, 2004. “Plant Succession in Areas Colonized by the Introduced Nootka lupin in Iceland” in *Wild and Cultivated Lupins from the Tropics to the Poles. Proceedings of the 10th International Lupin Conference, Laugarvatn, Iceland,19-24 June 2002*. International Lupin Association, Canterbury, New Zealand, pp. 170-177.

Mayer, P., 2006. “Biodiversity - The Appreciation of Different Thought Styles and Values Helps to Clarify the Term” in *Restoration Ecology*, 14, pp. 105-111.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Desertification Synthesis*. World Resources Institute, Washington, D.C.

Newman, G.J. and E.F. Redente, 2001. “Long-term Plant Community Development as Influenced by Revegetation Techniques” in *Journal of Range Management*, 54, pp. 717-724.

Noss, R.F., 1990. “Indicators for Monitoring Biodiversity - A Hierarchical Approach” in *Conservation Biology*, 4, pp. 355-364.

Novacek, M.J. and E.E. Cleland, 2001. “The Current Biodiversity Extinction Event: Scenarios for Mitigation and Recovery” in *Proceedings of the National Academy of Sciences of the United States of America*, 98, pp. 5466-5470.

Oddsdóttir, E.S., 2002. [*The Effects of Afforestation and Revegetation on Soil Biota*]. M.Sc. Theses. University of Iceland, Reykjavík (in Icelandic).

Olden, J.D., N.L. Poff, M.R. Douglas, M.E. Douglas and K.D. Fausch, 2004. “Ecological and Evolutionary Consequences of Biotic Homogenization” in *Trends in Ecology & Evolution*, 19, pp.18-24.

Orradottir, B., 2002. *The Influence of Vegetation on Frost Dynamics, Infiltration Rate and Surface Stability in Icelandic Andisolic Rangelands*. MS Thesis. Texas A&M University, College Station, Texas.

Orradottir, B. and Ó. Arnalds, 2007. [“Infiltration – Effects of Reclamation and Season”] in *Fræðaþing landbúnaðarins*, 4, pp. 513-515 (in Icelandic).

Oskarsson, H., O. Arnalds, J. Gudmundsson and G. Gudbergsson, 2004. “Organic Carbon in Icelandic Andosols: Geographical Variation and Impact of Erosion” in *Catena*, 56, pp. 225-238.

Palmer, M., E. Bernhardt, E. Chornesky et al., 2004. “Ecology for a Crowded Planet” in *Science*, 304, pp. 1251-1252.

Petursdóttir, T., 2007. [*Ecological and Visual Assessment of the Short-term Impacts of Revegetation*]. MS thesis, Agricultural University of Iceland (in Icelandic).

Pickart, A.J., L.M. Miller and T.E. Duebendorfer, 1998. “Yellow Bush Lupine Invasion in Northern California Coastal Dunes - I. Ecological Impacts and Manual Restoration Techniques” in *Restoration Ecology*, 6, pp.59-68.

Rogers, D.L. and A.M. Montalvo, 2004. *Genetically Appropriate Choices for Plant Materials to Maintain Biological Diversity. Report to the USDA, Forest Service, Rocky Mountain Region*. University of California, Lakewood, CO, pp. 343.

SER, 2004. *The SER Primer on Ecological Restoration*. Society for Ecological Restoration, Science and Policy Working Group.

Sigurðardóttir, H., 2004. “Earthworm Activity in a Lupin Patch in Heidmörk, Southern Iceland” in *Wild and Cultivated Lupins from the Tropics to the Poles. Proceedings of the 10th International Lupin Conference, Laugarvatn, Iceland, 19-24 June 2002*. International Lupin Association, Canterbury, New Zealand, pp. 191-194.

Thurow, T.L., W.H. Blackburn and C.A. Taylor, 1988. “Infiltration and Interrill Erosion Responses to Selected Livestock Grazing Strategies, Edwards Plateau, Texas” in *Journal of Range Management*, 41, pp. 296-302.

Thurow, T.L., W.H. Blackburn and J.R. Taylor, 1986. “Hydrologic Characteristics of Vegetation Types as Affected by Livestock Grazing Systems, Edwards Plateau, Texas” in *Journal of Range Management*, 39(6):505-509.

Wessels, K.J., S.D. Prince, M. Carroll and J. Malherbe, 2007. “Relevance of Rangeland Degradation in Semi-arid North-eastern South Africa to the Non-equilibrium Theory” in *Ecological Applications*, 17, pp. 815-827.

Whisenant, S.G., 1999. *Repairing Damaged Wildlands*. Cambridge University Press, Cambridge.

Wilcox, B.P. and M.K. Wood, 1988. “Hydrologic Impacts of Sheep Grazing on Steep Slopes in Semiarid Rangelands” in *Journal of Range Management*, 41, pp. 303-306.

Williamson, J. and S. Harrison, 2002. “Biotic and Abiotic Limits to the Spread of Exotic Revegetation Species” in *Ecological Applications*, 12, pp. 40-51.

Capacity Building for Developing Legal and Policy Frameworks for Soil Conservation and Protection

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Introduction

There has been significant activity in capacity-building approaches to improve the environmental law and policy for soil conservation and protection in recent years. The approaches described in this paper stem from international and national level investigations and reforms which have produced legal and policy frameworks, guidelines and legislative information on the sustainable use of soils and land degradation control. These approaches have developed from researching environmental law materials, experiences of national reforms, regional reforms and review by environmental law and scientific experts. Various international environmental law organizations have carried out the studies and reviews, especially the IUCN (The World Conservation Union) Commission on Environmental Law. At the international level, the main objective is to develop a clear picture of the environmental law, including the role of multilateral treaties and regional treaties, in soil protection, and prepare draft legal rules and commentaries and recommend ways to improve the international environmental law for sustainable use of soils. At the national level there have been investigations into the legal, policy and institutional aspects of soil protection in a number of countries, for example, the People's Republic of China, Iceland, Thailand, Australia, New Zealand, Kyrgyzstan, Tajikistan (Pamir-Alai eco-region) and the European Union (EU). Comprehensive legal and policy frameworks prepared by individual nations have emphasized integrated ecosystem management and sustainable use of soils. International training and workshops on techniques for analyzing national legislative systems for sustainable land management and sustainable use of soils have been held in a number of countries, for example, China, Iceland, Thailand, Tajikistan and Kyrgyzstan, and reports have been prepared on the legal and institutional systems for soil conservation in Australia, New Zealand, USA and the European Union. Recent investigations have commenced in the Balkans and Brazil. There is now a variety of legislative materials available on the status of soil conservation law and policy at the international and national levels, as well as associated training materials to assist countries to reform domestic laws and policies.

1. International Level

There has been considerable interest among the international soil science community to improve the law for soil conservation, in particular from the International Union of Soil Sciences, World Association of Soil and Water Conservation, European Soil Conservation Society and various regional soil science groups (Hurni and Meyer, 2002). A number of joint meetings have been held between soil scientists and environmental lawyers, and the 2005 workshop in Iceland to discuss international and national soil science and legislative issues was very progressive (SCAPE, 2005). A main area of activity is investigations by the IUCN Commission on Environmental Law (CEL) into the international law for soil conservation and protection, the role of various multilateral treaties and regional treaties in soil conservation (Hannam and Boer, 2002; Hannam and Boer, 2004), and guidelines for drafting soil legislation (Boer and Hannam, 2003). The CEL has prepared draft international legal rules for soil conservation and protection and an associated commentary (CEL, 2007). Other international organizations with an active role in soil conservation law and policy include the United Nations Environment Programme (UNEP) and the Food and Agriculture Organization of the United Nations.

The main objective at the international level of investigation is to clearly understand the capacity of international environmental law and policy to manage soil sustainably and to recommend where improvements can be made. The current international legal regime is summarized in the report *International Law for Soil Conservation* prepared by Working Group 5 of this Forum. The report outlines the main binding instruments, important Non-binding instruments and a number of other relevant initiatives; provides an overview of the existing international regime; and outlines the international environmental framework for sustainable use of soil, including a review of options, and a preparation of the draft legal guidelines and its commentary (Hannam and Boer, 2002; CEL, 2007).

1.1. Current framework

The current international environmental law regime has a number of inadequacies to cater to the principal international environmental law needs of soil. Existing binding instruments are insufficient as a framework for soil as they fall well short of including anywhere near a sufficient range of legal elements to protect and manage soil in a sustainable way and the environmental concepts and policy elements needed to achieve sustainable use of soil. Furthermore, the international environmental law regime does not provide any guidance to States to reform or develop national soil legislation. A number of key international environmental strategies and actions investigated in the development of an approach for an adequate international law regime include (Hannam and Boer, 2002; Hannam and Boer, 2004):

- The United Nations Conference on Environment and Development 1992, Agenda 21 1992;
- The UNEP Montevideo Programme III 2000;
- The Plan of Implementation of the World Summit on Environment and Development 2002;
- The World Soils Agenda 2002;
- Millennium Declaration 2000;
- The Committee for the Review of the Convention to Combat Desertification;
- The UNEP Strategy on Land Use Management and Soil Conservation 2004; and,

- The IUCN World Conservation Congress Resolutions on Sustainable Use of Soil October 2000 and November 2004.

The effective implementation of an international instrument for sustainable use of soil would, in turn, rely on individual countries having the capacity to develop the necessary policies, legislation and institutions, and to have access to properly trained staff resources. Through its integrated programme of activities, the IUCN Environmental Law Programme (ELP) provides decision-makers with information, legal analysis, advisory services, legislative drafting, mentoring and capacity-building at national, regional and global levels. The ELP provides the opportunity and the forum for governments, non-government organizations and others to network and share information and discuss ideas. In this regard, the IUCN CEL has been investigating methods to improve national soil conservation laws and the international law for soil conservation and, in response to the two "Soil Resolutions" passed by the IUCN World Conservation Congress (2000 in Amman, Jordan; 2004 in Bangkok, Thailand), the CEL Soil Law Group has reviewed international and regional instruments that make reference to soils and has summarized the relationships between different hard and soft law mechanisms. With increasing interest by the world community in soil and land degradation, there is now increasing recognition of the role of international environmental law to help manage these problems, including its ability to provide a juridical basis for action by nations and the international community. Various outcomes of the IUCN investigation are being utilized by individual countries to approach the development of new soil legislation (ADB, 2006).

1.2. Draft international rules

A main outcome of CEL Soil Law Group investigations is the draft set of international legal rules for the protection and sustainable use of soil. They have been developed with the input of the soil science community and discussed at meetings between soil scientists and environmental lawyers (SCAPE, 2005). The draft is promoted as an appropriate direction to take for an international law for soil. Moreover, at this point, the draft rules could be utilized by any country to guide the reform of soil conservation legislation. The rules, in the form of a legal framework, are to:

- Consolidate the elements of existing international instruments and soil policies;
- Provide guidelines on the legal, scientific and policy requirements for the ecologically sustainable management of soils;
- Forge links between soil law and other international environmental law instruments;
- Provide the motivation for States to legislate or reform national legislation on soil conservation, recognizing that soil is part of the biophysical environment; and
- Promote the development of guidelines for public participation and environmental education about soil conservation by forming an expert soil conservation panel.

In the above context, the draft rules include special provisions for:

- Establishing an expert panel for protection and sustainable use of soils;
- Community participation in the sustainable use of soil;
- Organizational systems to protect soil;
- Formation of national soil conservation strategies;
- Research into the protection and sustainable use of soil;
- Resolution of transboundary soil management issues; and
- Special rights for disadvantaged people to the use of soil.

2. National Level

Globally, many types of legislation have been used to manage soil problems, but the main type of legislation for the control of soil degradation has been "soil conservation law". This legislation had a land utilization focus and is no longer adequate for managing soil conservation issues in an integrated way. Also, the conservation capabilities of the legislation was overshadowed by the objective of agricultural production, price support schemes for domestic and export needs, and land settlement and development schemes. Initially, soil conservation legislation was introduced in the first half of the 19th century primarily to control the effects of soil erosion by wind and water that was prominent in colonial Africa, Australia, and New Zealand, the United States and some European and Asian nations. It was introduced to prevent, mitigate or manage soil erosion on arable or pastoral land, mainly at the farm level. Some of the legislation had provisions for land management planning at a river basin scale. Although national environmental law development expanded in general in the 1980s and 1990s, soil conservation law reform was not a prominent activity, and the legal and institutional frameworks in most countries still approach soil conservation in a weak and fragmented way. By mid-1990, in pursuance of a sustainable land management goal, it was acknowledged that a range of land management programmes, policies and educational initiatives, as well as national and local laws, were necessary to successfully change the behaviour of land users to achieve such a goal (Hannam and Boer, 2002). In the past 10 years, comprehensive legal, policy and institutional investigations and studies have been undertaken in this area of law in the People's Republic of China, Iceland, Thailand, Kyrgyzstan and Tajikistan. Other reforms have been undertaken by Australia, Japan, New Zealand, India (Boer and Hannam, 2003) and in the EU (Heuser, 2006a). National level approaches have included legal and policy frameworks for soil conservation and protection in both individual nations and some transboundary eco-regions with an emphasis on integrated ecosystem management.

2.1. Case examples

a) National reform – China

Two projects recently undertaken in China have developed new approaches in natural resource law reform.

(i) Soil conservation law

The investigation into a new national soil conservation law for China included an intensive study of international and national legislative information, guidelines and experiences from around the world to decide the approach to replace the China 1991 Water and Soil Conservation Law (ADB, 2006). The investigation established 20 key "principles" of international law that were used as the foundation for the new legislation (Hannam, 2006a). In addition, four national case studies show that some national laws have been reformed by introducing a broader ecological responsibility for the responsible agency (e.g. expanded role of the USA Natural Resources Conservation Service); whereas in other cases, the preference has been to incorporate soil conservation objectives within comprehensive integrated environmental law (e.g. New Zealand *Resource Management Law 1999*, and the Australian, South Australia *Natural Resources Management Law 2004*). Another key aspect to come out of the China approach is that many individual laws can contribute to a soil conservation objective and these can be effectively managed by a multi-disciplinary natural resources institution, with an ecosystem focus, using a variety of cooperative and financial mechanisms. The investigation nominated the following key areas as requiring attention by the new China soil conservation law (Hannam and Song Ying, 2006):

- The focus of the law, including its underlying philosophy;
- The general purpose and objectives of the new law;
- Improving organizational and administrative procedures;
- Provisions to improve education in resource protection;
- Provision for soil and water conservation research;
- Monitoring and auditing the functions in the new law;
- A clear role for the community in soil conservation;
- Special financial mechanisms for soil conservation;
- Citizens' right to information about soil conservation activity;
- Administrative procedures and role of environmental impact assessment (EIA) in soil conservation;
- Improved regulatory powers and compliance mechanisms;
- Improved dispute resolution mechanisms; and
- Provision for making regulations for soil and water conservation and resource protection.

(ii) Legal and policy frameworks for control of land degradation

The legal component of the People's Republic of China – Global Environment Facility (PRC-GEF) Partnership Project (the Project) was designed to assess and review laws and policies and determine their capacity to manage land degradation in six dryland provinces of western China. Investigations by the six provinces outline how to improve the laws and policies to the standard of best international environmental law practices, including recognition of rural property rights, providing security of land tenure, and protecting the rights and interests of individuals with regards to access and sustainable use of land resources (Hannam and Du Qun, 2007). Specialist legal and policy teams were formed in each province and a high-level Legal and Policy Expert Advisory Group provided overall guidance and direction for the legal and policy improvements. Over 200 laws and regulations from the six provinces and central area were analyzed using a technique which outlines the weaknesses, strengths and capabilities of individual laws and regulations for land degradation control (called the integrated ecosystem management (IEM) Method). The IEM Method was also applied to compare the relative capabilities between two or more laws. This information was used to prepare the new legal and policy framework for each province, highlighting new types of law for control of land degradation (Hannam and Qun Du, 2007).

(iii) Benefits of the new legal and policy framework

The provincial legal and policy frameworks are a management mechanism that gives the provinces practical information and guidance to understand, develop and strengthen the capacity of the legal and policy systems to control land degradation. They also establish the procedural basis to introduce integrated ecosystem management into the future law and policy-making procedure. The frameworks improve coordination between the legal and technical decision-making sectors for land degradation control, and are part of the provincial strategic planning process (Hannam and Du Qun, 2007). Items identified in the provincial frameworks for attention include:

- Developing an IEM-based philosophy for legislation and policy to combat land degradation;
- Improving the system of environmental impact and economic evaluation and analysis;
- Improving local and supporting laws for land degradation control;
- Establishing an ecological compensation system to restore and rebuild the ecosystems;
- Improving administrative law enforcement to protect the ecological environment;
- Establishing a litigation system of public interest;
- Reforming legislation for disadvantaged people including women, minorities, farmers and herders, including improved property rights, access to finance and knowledge;

- Preparing policies that involve the community in ecosystem protection;
- Introducing ecological and technical standards for land management;
- Developing financing mechanisms;
- Implementing land degradation control from small-scale to large-scale area treatments; and,
- Developing new strategies to improve coordination between integrated resource management departments.

b) Regional – Pamir-Alai Mountains

Environmental laws introduced in Kyrgyzstan and Tajikistan in the 1990s covered a range of environmental interests relevant to the Pamir-Alai region, but limited attention was given to specific mechanisms to protect soil resources and ecosystems from land degradation. Investigations found that the quality of environmental legislation, policy and institutional performance for sustainable land management in this region can be improved by introducing a “common boundary” regional trans-boundary approach. This would establish the legal, policy and institutional preconditions necessary for restoring ecosystem productivity and reducing poverty, and to establish the basis for cooperation and coordination in management of the region. The initial emphasis would be on improving the knowledge, skills and capacity of officials so that more effective national laws and policies can be developed for sustainable land management, and on improving the capacity of institutions to implement and monitor the laws. The following activities were used to identify existing legislative mechanisms and develop new, more appropriate mechanisms (Breu and Hurni, 2003; UNU, 2005a):

- Establishing procedures and mechanisms to improve the quality of law, policy and institutions to successfully implement sustainable land management;
- Providing training and education in legislative and policy aspects of land management; and,
- Accessing specialist policy, legal, and regulatory advice and problem-solving support, including legal and policy expertise to guide the implementation.

Key mechanisms identified included:

- Developing procedures to assess and improve sustainable land management in legislation, policy and institutional environment;
- Recommending ways to harmonize the laws and policy;
- Developing institutional capacity for implementing land management laws and policies;
- Assessing the role of environmental assessment and implementation procedures;
- Assessing legal and policy measures for community participation and stakeholder representation;
- Developing a programme of training workshops in environmental law and policy;
- Developing an environmental law and policy information system; and,
- Developing a joint mountain territories authority.

c) European Union

The current legal situation in the European Union (EU) does not provide an effective framework for soil protection (Heuser, 2006b). The existing legislation covers some aspects of chemical and biological soil protection, e.g. in the Sewage Sludge Directive, the Water Framework Directive, the Integrated Pollution Prevention and Control (IPPC) Directive, the Habitats Directive, as well as waste management law, but it remains fragmented and safeguarding soils is a secondary issue. EU law takes little account of the requirements to prevent soil compaction, erosion, sealing and other physical threats to soil. A new approach came with the 6th Environmental Action Programme which aims to develop a specific EU strategy for soil protection.

A European Community directive could be based on the principles of soil protection including information gathering, precaution and prevention, damage remediation and standardisation. The combination of regulative and non-regulative instruments, including planning, direct and indirect behaviour control, company organisation and civil and criminal law, would lead to more effective soil protection. From a political perspective, it seems realistic to assume that not all possible instruments for soil protection can be realised at the same time. A closer look at these possible EU instruments might be valuable for the development of legal approaches to soil protection at the national and international level as well. In 2002, a Communication from the Commission titled *Towards a Thematic Strategy for Soil Protection* outlined a Soil Protection Strategy which is based on the principles of precaution and prevention.

In September 2006, the Commission published a strategy which includes a procedure for assessing the current situation and outlining the proposal for Soil Framework Directive to address the key soil threats that were outlined in the Commission's initial Communication (i.e. organic matter, soil erosion and soil contamination) as well as the additional aspects of soil sealing, compaction, decrease of biodiversity, salinization, and floods and landslides. The Soil Protection Strategy and its Proposal of a Framework Directive are currently being discussed in the committees of European Parliament. In the course of these present activities at the European Union level, it is possible that this approach will see EU soil protection law develop into a ‘genuine’ soil protection policy at the European Union level (Heuser, 2006a; Heuser, 2006b).

3. Capacity-building and Training

International workshops on techniques for analyzing national legislation for sustainable land management and sustainable use of soils have been held in a number of countries in recent years including China, Serbia, Iceland, Tajikistan and Kyrgyzstan, and various training materials have been prepared (UNU, 2005b). Comprehensive reports have been prepared on the legal and institutional systems for soil conservation in Australia (Hannam, 2006b), New Zealand (Palmer, 2006; Grinlinton, 2005), USA (Futrell, 2006) and the European Union (Heuser, 2006a). Specifically, an IUCN Method has been developed as a key component of the capacity-building and training programmes of national officials.

The Method was developed from the assessment of hundreds of international and national natural resources laws to find the most appropriate “core” legal elements that should appear in an ideal law for land degradation control. It has been tested by a cooperative partnership of soil scientists and environmental lawyers working closely together. An element is defined as a principle or suggested rule or direction of conduct that may be used in its existing form or modified to perform the role of a legal mechanism (such as a direct statutory function or an administrative function), or as a legal principle (a rule of conduct) in legislation. An element can also be used singularly, or in combination with other legal mechanisms or principles, to enable or invoke a legally-based action to achieve sustainable land use. The 17 key principal legal elements selected are underpinned by the concept of sustainable land management, and they include: the general intent, jurisdiction, responsibility, goals and objectives, duty of care, institutional, policy, administrative structures, definitions, education, research and investigation, land planning, land management, community participation, financial mechanisms, dispute resolution, and enforcement (Hannam and Boer, 2002; Hannam and Boer, 2004).

The Method is applied to establish the capacity of an existing law or regulation to manage land degradation, where the “capacity” is determined by the number and type of essential legal and institutional elements present within the laws in a format that enables implementation of sustainable land management, and with the legal, administrative and technical capability to take some form of positive action for land degradation control. In some situations, the capacity may be direct and obvious. In other situations it will exist in a format that enables some form of indirect action. Capacity is represented in the form of legal rights, the type of legal mechanisms, and importantly, the number and comprehensiveness of the main essential elements mentioned above.

Conclusion

This paper has outlined a number of achievements reached around the world in capacity-building to improve environmental law and policy for the sustainable use of soils. There is now a better understanding of the international environmental law situation for soils, and various options and recommendations have been made for further improvements in the international law for soil, including making better use of key multilateral and regional agreements for soil management. There have been many very positive outcomes at the national level. The experience, knowledge and tools developed at this level from reforms in a number of countries and regions has provided methodologies and guidelines that can be used by even more countries to help develop their approaches to capacity-building and undertaking reforms of soil legislation and policy, A significant aspect of the capacity-building approaches has been a very successful cooperative partnership between soil scientists and environmental lawyers working together to ensure that soil scientific principles and standards are used in framing well-structured laws and policies, capable of practical implementation.

References

Asian Development Bank, 2006. *Technical Assistance to the People’s Republic of China for the Implementation of the National Strategy for Soil and Water Conservation.*

Boer, B. and I. Hannam, 2003. “Legal Aspects of Sustainable Soils: International and National” in *Journal of the Review of European Community and International Environmental Law.* 12(2): 149-163.

Breu, T. and H. Hurni, 2003. *The Tajik Pamirs: Challenges of Sustainable Development in an isolated Mountain Region*. Berne: Centre for Development and Environment (CDE), University of Berne, pp. 80.

Commission on Environmental Law of the IUCN, 2007. *Draft Protocol for Protection and Sustainable Use of Soil*, Version 30 June 2007.

Futrell, W., 2006. *United States Laws to Protect Soil and Water.* Technical Assistance to the People’s Republic of China for the Implementation of the National Strategy for Soil and Water Conservation, TA 4404.

Grinlinton, D., 2005. “Using Legal Methods and Strategies to Promote the Sustainable Use of Soil” in *Strategies, Science and Law for the Conservation of the World’s Soil Resources. International Workshop, Selfoss, Iceland*. European Union.

Hannam, I. and B. Boer, 2002. *Legal and Institutional Frameworks for Sustainable Soils: A Preliminary Report*. IUCN, Gland, Switzerland and Cambridge, UK.

Hannam, I. and B. Boer, 2004. *Drafting Legislation for Sustainable Use of Soils: A Guide*. IUCN, Gland, Switzerland and Cambridge, UK.

Hannam, I. and Du Qun, 2007. “Environmental Law Reform to Control Land Degradation in the People’s Republic of China: A View of the Legal Framework of the GEF-PRC Partnership Programme” in N. J. Chalifour, P. Kameri-Mbote, Lin Heng Lye and J. R. Nolon (eds.), *Land Use Law for Sustainable Development.* Cambridge University Press, Cambridge, UK.

Hannam, I., 2006a. *Working Paper 1: International Laws and Regulations for Soil and Water Conservation*. Technical Assistance to the People’s Republic of China for the Implementation of the National Strategy for Soil and Water Conservation, TA 4404.

Hannam, I., 2006b. *Working Paper No 2: Case Study: Soil and Water Conservation Law in Australia*. Technical Assistance to the People's Republic of China for the Implementation of the National Strategy for Soil and Water Conservation, TA 4404.

Hannam, I. and Song Ying, 2006. *Report and Recommendations on Revising the 1991 Water And Soil Conservation Law of the People's Republic of China*. Technical Assistance to the People's Republic of China for the Implementation of the National Strategy for Soil and Water Conservation, TA 4404.

Heuser, I., 2006a. *Overview of Soil and Water Protection Law of the European Union,* Technical Assistance to the People's Republic of China for the Implementation of the National Strategy for Soil and Water Conservation, TA 4404.

Heuser, I., 2006b. "Milestones of Soil Protection in EU Environmental Law" in *Journal for European Environmental and Planning Law*, 3:3:190-203.

Hurni, H. and K. Meyer (eds.), 2002. *A World Soils Agenda, Discussing International Actions for the Sustainable Use of Soils*. Prepared with the support of an international group of specialists of the IASUS Working Group of the International Union of Soil Sciences (IUSS), Centre for Development and Environment, Berne, pp. 63.

Palmer, K., 2006. *Paper 1: Soil and Water Conservation in New Zealand.* Technical Assistance to the People's Republic of China for the Implementation of the National Strategy for Soil and Water Conservation, TA 4404.

Soil Conservation and Protection of Europe (SCAPE), 2005. *Strategies, Science and Law for the Conservation of the World's Soil Resources, International Workshop Selfoss, Iceland*. European Union.

United Nations University, 2005a. *Synthesis Report: the Legal, Policy and Institutional Aspects of Sustainable Land Management in the Pamir-Alai Mountain Environment*. Sustainable Land Management in the High Pamir and Pamir-Alai Mountains GEF PDF-B Project, United Nations University, Tokyo.

United Nations University, 2005b. *Training Manual on Methodological Framework for Analysing the Capacity of Legal, Policy and Institutional Aspects of Sustainable Land Management in the Pamir-Alai Mountain Environment.* Sustainable Land Management in the High Pamir and Pamir-Alai Mountains GEF PDF-B Project, United Nations University, Tokyo.

A Global Systems Approach for Healthy Soils

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1. Healthy Soils in a Global Context

"Soil – the living skin of planet earth" is how the International Union of Soil Sciences publicises the critical role of soil as a life-support for humankind (IUSS, 2008). Grasping that role has, however, been problematic for the soil sciences. Traditionally, the discipline has been beset by reductionism; that is, the approach to understanding its complex nature by reducing soil to its constituent parts, and reducing explanations of soil processes to their simplest possible entities (Keeney, 2000). This has led to technologies that seek to solve one problem – for example, lack of plant-available water by applying irrigation – while creating even greater problems such as soil and water salinity. It is, therefore, unsurprising that the application of soil science in practical tools, techniques and approaches should have had little impact on current priority topics such as the control of land degradation and the promotion of sustainable land management.

New paradigms are now seeking to reverse reductionist thinking and reinstate more holistic views of soil and its functions, even though the concepts can be difficult to grasp and complicated to put into practice (Sojka et al., 2001). Two terms, 'soil quality' and 'soil health', are becoming commonplace in the new thinking by importing ideas from ecology and ecosystems science. The terms are increasingly being used to characterise the ability of soils to perform vital ecosystem functions (Schloter et al., 2003; Enriqueta Arias et al., 2005; Prosser et al., 2006). The first term tends to be used more pragmatically in the context of a soil's capability for agricultural production and harvestable yield, and will often refer to soil nutrient content either organically or inorganically. The second, the focus in this paper, is broader, taking in the full array of ecosystem functions and services provided by the soil, including support, for example, to global environmental services such as the conservation of biodiversity and the mitigation of climate change. 'Soil health' is usually related to a soil's biological processes, including soil microbial and animal populations, and especially the biological diversity in the soil ecosystem that sustains plant and animal productivity, maintains water and air quality, and supports human livelihoods and well-being (Stocking, 2002). Healthy soils require holistic approaches; sustainable landscapes need a breadth of vision that spans the natural and social sciences, interdisciplinarity, temporal and spatial scales, and linkages to development discourses and policy platforms.

The underlying principle in 'soil health' is that soil is a biodiverse, dynamic entity that underwrites the services from the land required by humans (Altieri, 1999). To achieve a healthy state, the soil requires management – sustainable land management (SLM) – in such a way that its functioning is maintained, largely through biological processes and organic substances (Doran and Zeiss, 2000). It is the soil biology that develops the chemical and physical attributes that sustain the service functions. A healthy soil resists degradation; its built-in resilience enables some tolerance in its use, counteracting the natural and human-induced variability in climate, and supporting the soil's ability to cope with cultivation and other necessary mechanical operations.

This paper sets out a vision for a global systems approach to the complex issues around sustainable land management. It examines the synergies between global environmental and development goals, and demonstrates how approaches to land degradation should harness multiple beneficial impacts to achieve what is implied by the term 'healthy soils'. The new focal area Strategy for Land Degradation is outlined to illustrate how the Global Environment Facility (GEF) is contributing both resources and scientific efforts to delivering SLM.

2. A Systems Approach to Sustainable Land Management

A systems-oriented approach to SLM must deal with the "increasingly wicked and messy world in which natural resource planners function" (Lachapelle et al., 2003: 473). So, not only must any approach be holistic and rational, it must also be practical and pragmatic. The inter-linked demands for technologies to control land degradation, the development of SLM practices, the legitimate needs for human development, especially of the rural poor, and policy application, must all be captured. The approach must also link with the other primary global environmental agendas for biodiversity and climate change. In addition, it should cut across scales of application at global, regional, national and local levels, as well as provide temporal security through ecological, economic, social and institutional sustainability. These are considerable demands, requiring broad sets of skills drawn from many disciplines and a strong emphasis on capacity-building. Figure 1, originally presented at the SCAPE (Soil Conservation and Protection for Europe) Workshop in Iceland in 2005, attempts to position these components and suggests four points of intervention where SLM might be promoted.

There are three primary ways to achieve a systems approach in SLM, described here.

2.1. Identify practical interventions

In Figure 1, the main points of practical intervention are labelled: 1) Techniques and approaches; 2) Knowledge and research; 3) Strategies and policies; 4) Laws and institutions. These actions require different temporal and spatial scales to become effective. The growing threat of food insecurity, especially for the poor and vulnerable populations in developing countries, necessitates immediate action (Lal, 2009). This means identifying technological options for SLM that bring greater benefits than costs. Such an optimised situation is difficult to gauge because costs are often incurred locally, while the benefits accrue nationally and globally, thus necessitating transfers of money as in schemes under the CDM (Clean

Development Mechanism) and in PES (Payment for Environmental Services) (see Wunder, 2005; FAO, 2007). The record of these types of schemes operating efficiently is, however, poor (Ferraro and Simpson, 2002).

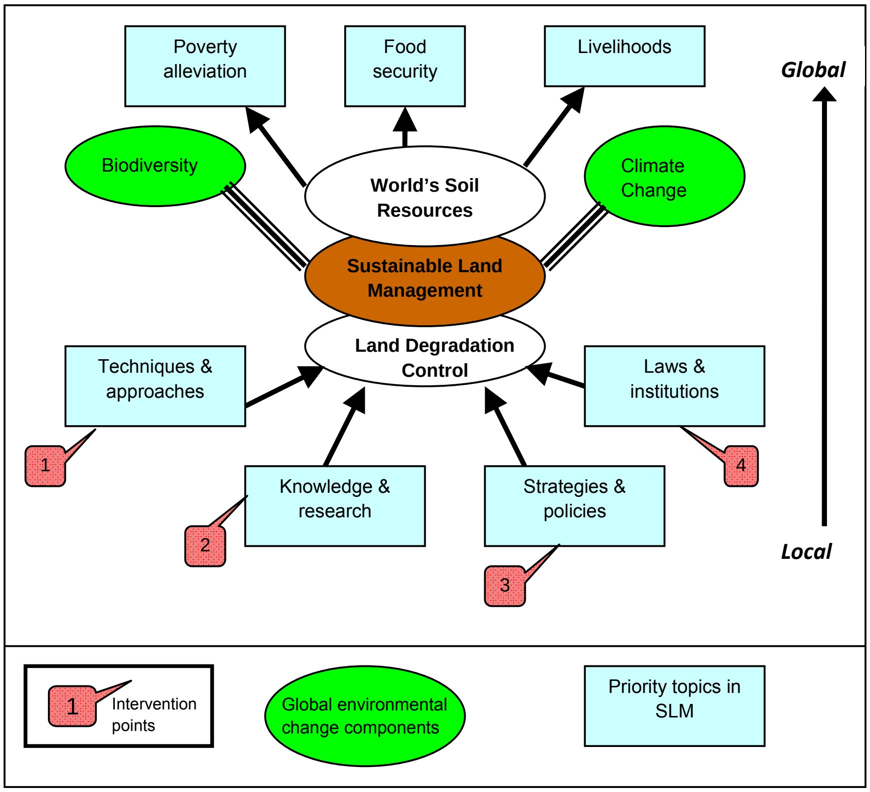

Figure 1. A conceptual view of the linkages and components in sustainable land management – from local to global issues (adapted from author's SCAPE Workshop presentation, Iceland, 2005).

Nevertheless, technological innovation for SLM is possible and leading contenders currently (see Lal, 2009: 2) include:

(i) No-till farming based upon the use of crop residue mulch and cover crops for conserving water and enhancing soil organic matter through techniques such as bio-char and other amendments. Note that crop residues and other organic sources are often used by the poor for fuel or feeding livestock – so there can be a considerable cost.
(ii) Water harvesting and recycling along with irrigation and appropriate species selection that can tolerate drought. Note again that issues such as access to suitable seed and materials are common problems.
(iii) Leguminous cover crops in the rotation cycle, and the introduction of trees (agroforestry). Note that this may decrease the available area for food crops where land is scarce.
(iv) Integrated nutrient management options based upon the use of compost and manure, biological nitrogen fixation, biosolids and enhanced fertilizer sources with slow-release formulations. Again, many of these technological options incur considerable costs to small farmers, especially in terms of labour and access to materials and information.

The Millennium Ecosystem Assessment estimates that some 60% of ecosystem services based upon land resources are either degraded or being used unsustainably (MA, 2005). A large proportion of this is soil degradation, the control of which lies at the heart of 'healthy soils'. Soil degradation manifests itself in many forms, including (in approximate order of prevalence but noting that many of these processes co-exist) depletion of soil organic matter, decline in soil water holding capacity, accelerated soil erosion by water, loss of soil structure, wind erosion, nutrient imbalance, water logging and salinity. Table 1 lists the common technological options for the principal degradation processes. These options need to be assessed not only for their technical performance but also their rationality for the farmer. Soil and water conservation techniques have been beset by problems of rationality and affordability as illustrated in a study in semi-arid Kenya which showed that only one technique, trashlines of weeds along the contour, brought enough benefits to the land user to be worth promoting (Kiome and Stocking, 1993). Revealingly, 'trashlines' was the one technique not promoted by the agricultural extension services.

Table 1. Soil degradation and options for reducing impact.

Process Component	Type of soil degradation	Improvement measures
Physical soil management	Crusting; Compaction Sealing Wind erosion; Water erosion Devegetation Overtillage	Live barriers; Terracing; Revegetation of denuded land Tree protection; Soil decompaction Breaking up pans; Cover crops Windbreaks; Soil deposition Improved tillage methods
Soil water management	Impeded drainage; Waterlogging Reduced water-holding capacity Reduced infiltration Salinization	Irrigation; Water harvesting Field drainage; Draining of waterlogged areas; Filter strips
Soil nutrient and organic matter management	Alkalinization; Acidification Nutrient leaching Removal of organic matter Burning of vegetative residues Nutrient depletion	Fertilization; Composting Green manuring; Animal manuring Flushing of saline/alkaline soils Liming acid soils
Soil biology management	Over-application of agrochemicals Industrial contamination	Introduction of biotic organisms Nitrogen-fixing microorganisms
Vegetation management	Decline in vegetative cover Decline in biodiversity Decline in species composition Decline in valued species	Increased vegetative cover Increased species diversity Improved species composition Improved availability of valued species

The other intervention points identified in Figure 1 (labelled 2, 3 and 4) are all part of the policy environment, requiring mainstreaming of strategies, policies, institutional support and legal frameworks for SLM. Some studies (e.g. Rockefeller Foundation, 2006) advocate the need for a Second Green Revolution in order to feed the current global population of 6.7 billion, projected to increase to 9.2 billion by 2050. Other initiatives seek new partnerships, including governments and philanthropists, local people and non-governmental organizations (NGOs). The Bob and Melinda Gates Foundation, which is leading a renewed focus on research and agricultural development, is trying a collaborative approach, putting local women at the centre of support structures, while using science and analytical data to develop new technological approaches[1]. SLM can only benefit by these more holistic and integrative initiatives.

2.2. Relate SLM to global development agendas

Approximately 1.4 billion people worldwide inhabit fragile lands, of whom 1.3 billion live in developing countries (World Bank, 2003). There is often a close association between the distribution of poor people reliant on agriculture and the location of fragile and degraded environments. Poorer people in a community, region or country are likely to be farming the steeper land, the drier less fertile soils or those areas remote from the settlements where forest still exists to be cut down. Fragile environments are more susceptible to land degradation, and poorer people are relatively less able to practice sustainable land management. Indeed, there is a significant risk of a downward spiral of environmental degradation leading to poverty, and more poverty leading to further environmental degradation. The world's 'badlands' attest to this.

Take, for example, the link between land degradation and Gross Domestic Product (GDP) (see McDonagh et al., 2006). About 70% of poor people in developing countries live in rural areas and depend directly or indirectly on agriculture for their livelihoods. The relationship between the GDP of a nation and its dependence on agriculture is negative. The Food and Agriculture Organization (FAO) calculates that the world's average GDP per capita was $5,752 in 2002, and the average contribution of agricultural output to national GDP was 4%. For those nations with a per capita GDP less than half of the world average, the average agricultural share in total GDP was 25% (FAO, 2004). This strong reliance of poor countries and the poor within countries on agriculture and other natural resources-based activities is supported by other studies. In Tanzania, it was found that, although the average percentage of rural household income derived from agriculture was already quite high at almost 50%, this figure rose to 70% for the poorest income quartile (Ellis and Mdoe, 2003). These findings emphasise the relatively high sensitivity of the poor to land degradation and other forms of natural resource degradation. The impact of land degradation on GDP is difficult to quantify precisely and few studies have tried to do this. In one analysis, undertaken in seven developing countries in Africa, Asia, and Latin America, Berry et al. (2003) estimated that the problems of sustainable land management reduced agricultural GDP by 3-7%.

Therefore, SLM must not only relate to development but it must also make a positive contribution to alleviating poverty and human suffering. It is now recognized that actions to combat desertification directly are unlikely to succeed unless accompanied by investments to promote economic well-being and local livelihoods (UNCCD, 2008).

[1]Please see http://www.gatesfoundation.org/topics/Pages/agricultural-development.aspx.

2.3. Find synergies with other focal areas

Linkages exist between all three of the original global environmental change components determined back in 1992 at the Rio Earth Summit – biodiversity, climate change and land degradation. If one component changes, the other two also change, usually in unison and in the same direction, positively or negatively (Gisladottir and Stocking, 2005). Grasping the opportunities of this is a major step forward in justifying land degradation control as a legitimate global change topic rather than a solely local or domestic issue. It leads the way to land degradation control being an entry point or lever to addressing practical issues of climate change control and protection of biodiversity through local measures such as soil conservation and re-forestation. It leads also to a conclusion that land degradation control might be better pursued as part of poverty alleviation and food security programmes, both of which have far better resonance in the international community and greater likelihood of funding and acceptance.

In the jargon of global environmental change, these linkages both with the global environment and global development agendas are called ‘synergies’. The term expresses the hope that quantitative beneficial impacts can be achieved simultaneously, thereby making investments in land degradation control cost-effective provided that the range of beneficial impacts are captured and quantified. The combined global effect is greater than the sum of the individual global change effects. A focus on linkages is therefore essential. Interlinkages and the so-called ‘drivers of change’ are fundamental in understanding how approaches to land degradation control may be designed and implemented (Berry and Olson, 2001).

3. The GEF Focal Area Strategy for Land Degradation

In 2002, the GEF mandate was expanded to include the control of land degradation as a focal area to support the United Nations Convention to Combat Desertification (UNCCD). SLM then became financially supportable under the GEF: in the second GEF replenishment (1999-2002), an allocation of US$ 278 million was for land degradation linkage projects, of which there were 103; and in the third replenishment (2002-2006), US$ 500 million was allocated, half of which went directly to the focal area and half for cross-cutting activities with other focal areas. The focus was firmly on promoting sustainable land management through integrated approaches to natural resources management, covering all the major rural land use systems: agriculture, rangeland, and forestry (Berry and Lusigi, 2006). Yet, it was clear that the GEF still struggled with the legitimacy of land degradation control and SLM bringing global benefits (Stocking, 2006).

For the fourth replenishment (2006-2010), the GEF allocation to the land degradation focal area was reduced to US$ 300 million. Given the scale and intensity of land degradation, this finance cannot possibly meet the costs of prevention, control and reversal of land degradation in all affected areas. The Strategy, therefore, was to allocate the available resources selectively. Rehabilitation of already-degraded lands or the development of control technologies would not receive money, as both these lack either cost-effectiveness or are better supported by other agencies. The landscape approach, which embraces ecosystem principles, would instead be used to address processes that provide people with ecosystem goods and services at the local to global scales of operation. Priority would be given to areas which: (a) are severely affected by land degradation but have potential for the creation of an enabling environment for SLM; and, (b) show promising improvements that can be spread to neighbouring areas and other communities.

The Desertification Synthesis of the Millennium Ecosystem Assessment (MA) (2005) and subsequent analyses (e.g. Douglas, 2006) have highlighted *inter alia* two principal barriers to effective action to combat land degradation: a weak policy and institutional environment that marginalises effective actions through a lack of national prioritisation of the issues of sustainable land management; and, a failure to appreciate the leverage on national development that could be achieved through targeted SLM interventions that would bring multiple benefits to a number of sectors simultaneously. Subsequent analyses have supported the finding that these barriers, along with deficiencies in the global institutions tasked with tackling the problem, are major impediments to controlling land degradation (e.g. Stringer, 2008).

Therefore, two Strategic Objectives were developed by the GEF to build a policy and institutional environment conducive to prevention and control of land degradation and to encourage effective actions on the ground (Table 2, Column 1). These two objectives were designed to channel investments to priority areas – both in developing examples of good practice in areas not yet degraded and addressing the more problematic and highly-degraded agro-ecological zones. They are supported by a number of challenging expected outcomes and impacts (Table 2, Columns 2 and 3). In order to make these objectives operational, the GEF-4 Strategy devised three Strategic Programmes to act as global envelopes for both programmes and projects (see GEF, 2007 and Table 3 for further details and descriptions of the Programmes). At this half-way stage in GEF-4 (2008), Strategic Programmes Nos. 1 and 2 have received a large number of proposals, whereas No. 3 has had few.

The GEF Overall Performance Study, currently (2009) underway, as a prelude to the negotiations for the Fifth Replenishment, will make an assessment of the achievements of the new global strategy. ‘Healthy soils’ will only be a sub-text as to whether (i) enabling environments to achieve SLM have been fostered, and (ii) mutual benefits have been derived for both the global environment and human development. The increased investment into land resources, including the soil, will have had considerable benefits and there is already an indication that soils and land management have risen in the priorities of many developing and developed countries. But there is much that remains to be done.

Table 2. Land degradation focal area Strategic Objectives with their expected impacts and indicators (source: GEF, 2007).

Impacts / **Strategic Objectives**	**Expected Impact**	**Impact Indicators**
Strategic Objective 1: An enabling environment will place SLM in the main stream of development policy and practice at regional, national and local levels. **Strategic Objective 2:** Mutual benefits for the global environment and local livelihoods through catalyzing SLM investments for large-scale impact.	Overall decrease in trend and/or severity of land degradation.	**% Increase in Net Primary Productivity (NPP) and Rain-use Efficiency (RUE)**
	Protected ecosystem functions and processes, including carbon stocks in the soil, plants and biota, and fresh water.	**% Increase in carbon stocks (soil and plant biomass) and/or % availability of fresh water**
	A decrease in the vulnerability of local populations to the impacts of climate change.	**% decrease in mortality rates consequent upon crop failures and livestock deaths**
	Improved livelihoods of rural (usually resource-poor) land users.	**% decrease in number of rural households below the poverty line**
	Diversified funding sources for SLM.	**% increase in diversity of funding sources (e.g. private sector, CDM)**

Table 3. Summary of Strategic Programmes for GEF-4 (source: GEF, 2007).

Strategic Programme	**Expected Programme Outcome**	**Programme Outcome Indicators**
1. Supporting Sustainable Agriculture and Rangeland Management	In intervention areas, an enabling environment for sustainable rain-fed crop production and rangeland management is created and natural resources (incl. dryland forests, water and energy) are managed in an integrated way.	• Each partner country has a new harmonised policy for each major land use type (agriculture, livestock) and/or has adopted a national land use policy. • % of extension programmes offered by key institutions reflects ecosystem principles and concepts. • % increase in joint activities between specialized institutions. • % increase in allocation of resources to sectoral ministries dealing with natural resources. • Net and *per caput* access of rural land users to rural credit facilities and/or revolving funds. • % increase in areas where SLM best practices are applied.
2. Supporting Sustainable Forest Management (SFM) in Production Landscapes	Forest resources in humid forest margins, forest fragments and woodland resources in semi-arid and sub-humid ecosystems are managed sustainably as part of the wider landscape.	• Each partner country adopts a new harmonised policy for SFM and/or a national land use policy. • % of extension programmes offered by key institutions reflects ecosystem principles and concepts in wider landscape management, including forest and woodland resources. • % increase in allocation of resources to sector ministries dealing with forest and woodland resources. • % increase in net and *per caput* access of forest- and woodland-dependant land users to rural credit facilities and/or revolving funds. • % increase in area where SFM best practices are applied.
3. Investing in New and Innovative Approaches in Sustainable Land Management	Enhance scientific and technical knowledge of emerging issues, facilitating the strategy discussion for GEF-5 and enhancing GEF operations in the land degradation focal area.	• Newly created scientific and technical knowledge supports strategy discussion for GEF-5. • % of designs of project to be financed in GEF-5 that reflect new scientific and technical knowledge. • New knowledge assists % of GEF-4 financed projects in preparation and implementation.

4. Delivering Healthy Soils

The intention of the global systems approach is to derive mutual benefits for local people and the global environment. While 'healthy soils' cannot be the ultimate goal, they will be an important by-product of re-engaged investment in sustainable land management and human development (IUSS, 2006). Soil health should be part of the agenda for SLM, involving (abridged from World Bank, 2006: xiv):

- preserving and enhancing the productive capabilities of the land in cropped and grazed areas; sustaining productive forests; and maintaining the integrity of watersheds for water supply and hydropower;
- actions to reverse land degradation – or mitigate the adverse effects of earlier misuse – especially where pressure of population is severe, and where the destructive consequences of upland degradation are being felt downstream.

The quality of soil is central to the achievement of this demanding agenda. Because soils support a huge diversity of organisms, the soil biology is in turn essential for the global environmental agenda. It is one of life's ironies that the smallest living organisms that give soil its health influence humankind at the global level. Only a global strategy for healthy soils can deliver the needed programmes, projects and activities.

References

Altieri, M.A., 1999. "The Ecological Role of Biodiversity in Agro-ecosystems" in *Agriculture Ecosystems and Environment* 74: 19-31.

Berry, L. and W. Lusigi, 2006. *Sustainable Land and Water Management: A GEF Agenda for Combating Environmental Degradation and Promoting Sustainable Livelihoods.* Report prepared for the Third General Assembly, Cape Town. Global Environment Facility, Washington, D.C., pp. 59.

Berry, L. and J. Olson, 2001. *GEF Land Degradation Linkage Study.* Working Paper 6. Global Environment Facility, Washington, D.C.

Berry L., J. Olson and D. Campbell, 2003. *Assessing the Extent, Cost and Impact of Land Degradation at the National Level: Findings and Lessons Learned from Seven Pilot Case Studies*. Report commissioned by the Global Mechanism with the support of the World Bank, Washington, D.C.

Doran, J.W. and M.R. Zeiss, 2000. "Soil Health and Sustainability: Managing the Biotic Component of Soil Quality" in *Applied Soil Ecology* 15: 3-11.

Douglas, I., 2006. "The Local Drivers of Land Degradation in South-East Asia" in *Geographical Research* 44: 123-134.

Ellis, F. and N. Mdoe, 2003. "Livelihoods and Rural Poverty Reduction in Tanzania" in *World Development* 31:1367-1384.

Enriqueta Arias, M., José A. González-Pérez, F.J. González-Vila and A.S. Ball, 2005. "Soil Health - A New Challenge for Microbiologists and Chemists" in *International Microbiology* 8: 13-21.

FAO, 2004. *Carbon Sequestration in Dryland Soils*. World Soils Resources Reports 102,
Food and Agriculture Organization of the United Nations, Rome.

FAO, 2007. *The State of Food and Agriculture: Paying Farmers for Environmental Services.* Report. Food and Agriculture Organization of the United Nations, Rome. Available at: http://www.fao.org/docrep/010/a1200e/a1200e00.htm.

Ferraro, P. and R. Simpson, 2002. "The Cost-effectiveness of Conservation Payments" in *Land Economics* 78: 339-353.

GEF, 2007. *Focal Area Strategies and Strategic Planning for GEF-4.* Council Document GEF/C.31/10, Global Environment Facility, Washington, D.C. Available at: http://www.gefweb.org/uploadedFiles/Documents/Council_Documents__(PDF_DOC)/GEF_31/C.31.10%20Focal%20Area%20Strategies.pdf.

Gisladottir, G. and M. Stocking, 2005. "Land Degradation Control and the Global Environmental Benefits" in *Land Degradation and Development* 16: 99-112.

IUSS, 2006. *The Future of Soil Science*. International Union of Soil Sciences, 176pp.

IUSS, 2008. *Soil – The Living Skin of Planet Earth*. International Union of Soil Sciences, pp. 2.

Keeney, D., 2000. "Soil Science in the Last 100 Years: Introductory Comments" in *Soil Science* 165: 3-4.

Kiome, R. and M. Stocking, 1993. *Soil and Water Conservation in Semi-Arid Kenya*. Bulletin 61, Natural Resources Institute, Chatham, pp. 59.

Lachapelle, P.R., S.F. McCool and M.E. Patterson, 2003. “Barriers to Effective Natural Resource Planning in a ‘Messy’ World” in *Society and Natural Resources* 16: 473-490.

Lal, R., 2009. “Soils and World Food Security” in *Soil and Tillage Research* 102: 1-4.

McDonagh, J., M. Stocking and Y. Lu, 2006. *Global Impacts of Land Degradation.* Report prepared for the Scientific and Technical Advisory Panel, Global Environment Facility, Washington, D.C., pp. 67.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Desertification Synthesis*. World Resources Institute, Washington, D.C.

Prosser, J.I., C.D. Campbell and K. Killham, 2006. *Soil Quality and Soil Health – What Do They Mean and How Should We Measure Them?* UK Population Biology Network. Available at: http://bioltfws1.york.ac.uk/UKPopNet/workshops/rw17.

Rockefeller Foundation, 2006. *Africa’s Turn: A New Green Revolution for the 21st Century*. Rockefeller Foundation, New York, pp. 10. Available at: http://www.rockfound.org/Library/africas_turn.pdf.

Scholter, M., O. Dilly and J.C. Munch, 2003. “Indicators for Evaluating Soil Quality” in *Agriculture, Ecosystems and Environment* 98: 255-262.

Sojka, R.E., D.R. Upchurch and N.E. Borlaug, 2001. “Quality Soil Management or Soil Quality Management: Performance versus Semantics” in *Advances in Agronomy* 79: 1-68.

Stocking, M., 2002. “Agrodiversity, Environmental Protection and Sustaining Rural Livelihoods: The Global View” in Brookfield, H., C. Padoch, H. Parsons and M. Stocking (eds.), *Cultivating Biodiversity: Understanding, Analysing and Using Agricultural Diversity.* ITDG Publishing, London, pp. 26-40.

Stocking, M., 2006. *Land Degradation as a Global Environmental Issue: A Synthesis of Three Studies Commissioned by the Global Environment Facility to Strengthen the Knowledge Base to Support the Land Degradation Focal Area.* Report for GEF Council, 5-8 December, Document GEF/C.30/Inf.8. Scientific and Technical Advisory Panel, Global Environment Facility, Washington, D.C., pp. 17.

Stringer, L., 2008. “Can the UN Convention to Combat Desertification Guide Sustainable Use of the World's Soils?” in *Frontiers in Ecology and the Environment* 6: 138-144.

UNCCD, 2008. *Desertification – Coping with Today’s Global Challenges in the Context of the Strategy of the United Nations Convention to Combat Desertification.* High Level Policy Dialogue, Bonn. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, pp. 47.

World Bank, 2003. *World Development Report 2003: Sustainable Development in a Dynamic World.* International Bank for Reconstruction and Development, Washington, D.C., pp. 231.

World Bank, 2006. *Sustainable Land Management: Challenges, Opportunities and Trade-offs.* International Bank for Reconstruction and Development, Washington, D.C., pp. 87.

Wunder, S., 2005. *Payments for Environmental Services: Some Nuts and Bolts.* CIFOR Occasional Paper No. 42, Center for International Forestry Research, Bogor, pp. 24. Available at: http://www.cifor.cgiar.org/publications/pdf_files/OccPapers/OP-42.pdf.

The Economics of Ecosystem Services

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Introduction

Deteriorating ecosystems generate economic, social and societal costs that are often very high, even though quantification of these costs has been a major challenge. The decision-making processes require sound valuation of potential development projects and economic investments in terms of ecosystem services quantity and quality.

The Millennium Ecosystem Assessment (MA) (2005) provides a detailed classification of the various ecosystem services into four areas, namely:

- Supporting services, such as primary production and soil formation;
- Provisioning services, including food, water, fibre and fuel;
- Regulating services, such as climate, water and disease regulation; and,
- Cultural services, including spiritual aesthetic, recreation and education.

This classification is currently the basis being used as by all experts working on the valuation of ecosystem services for operational purposes (Paggiola et al., 2004).

These services are of great importance to the well-being of the rural population in developing countries, particularly in Africa. A reflection by the World Bank (2006) on *Where is the Wealth of Nations* reported that natural capital accounts for 29% of total capital in low-income countries, 24% in sub-Saharan Africa, while it accounts for only 2% of total capital in high-income countries; thus, the great challenge of preserving natural resources and their various services in developing countries.

1. The Valuation of Land and Ecosystem Degradation in African Countries

Several studies have focused on how to value ecosystem services and the different aspects to be considered and calculated, relying on previous works in the field of economics of environment and natural resources. These previous attempts are often limited by a rather poor comprehension of the ecosystems' complexity. Whereas production services and their economic valuation in terms of methods and results are available, regulatory services remain to be enlightened through an improved knowledge of ecosystems' functioning by including human activities as part of the ecosystem, both as a service user and provider. To better understand this, the focus will first be on the valuation of decreased ecosystem services for arid areas through a reflection of the earlier methods and results obtained.

From the review of the existing estimation of land degradation costs in Africa, two methods have been discussed for assessing economic losses (Requier-Desjardins, 2007). They include:

a) Models of rainfall erosion processes on cultivated surfaces based on measurements of mean soil loss and crop yield reductions per hectare per annum. The yields lost are assessed by relating them to nitrogen losses or production losses due to erosion, which are then estimated into monetary value. The losses in these territories are then estimated, and the total loss calculated.

b) Spatial approach that divides the affected land surfaces according to their main economic uses (crops, livestock breeding and forestry). The total losses to rural production are obtained by applying a rate of decline in the natural productivity on the areas of interest. The only estimate of the annual loss to the global economy due to desertification was done by Dregne and Chou (1992), who estimated the value at US$ 42 billion (1990 values).

Figure 1 and Table 1 present the results obtained from the estimates of land degradation annual costs for various African countries and the methodologies used.

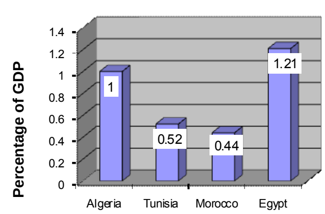

Figure 1. The cost of desertification for four North African countries (as a percentage of Gross Domestic Product, 2003). Desertification is defined here as soil degradation and deforestation costs. Source: République Algérienne Démocratique et Populaire (2002); World Bank (2002); République Tunisienne (2003); Royaume du Maroc (2003).

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In Figure 1, the valuations made for four countries of North Africa used the second method for quantifying the annual cost of desertification by making a distinction between three economic sectors: agriculture, pastures for breeding, and forests. These four estimates relied on the data available and estimates by experts. There is variation in annual losses suffered by the North African countries due to desertification, for example, 0.44% and 1% of Gross Domestic Product (GDP) for Morocco and Algeria, respectively.

There are also estimates for several sub-Saharan countries using various methodologies (Table 1). They mostly depend on:

- Data arising from implemented research and development projects; and,
- Administrative data from ministries and research institutions (census, spatial mapping etc.).

Table 1. The cost of land degradation in some of the sub-Saharan countries. Source: Bojö, 1996; Berry et al., 2003.

Country, year	Type of loss	Cost AGDP*	Main Elements and Methodology
Rwanda, 2003	Agriculture	3,5%	Agricultural Production; loss of human productivity
Ethiopia, 2003	Agriculture, Livestock, Forest	4%	Depth of soil related to loss in productivity
Ethiopia, 1986	Agriculture	<1%	Modelling of crop; Water Requirement satisfaction
Zimbabwe, 1994	Agriculture	<1%	Modelling of plants' growth and erosion mapping
Zimbabwe, 1992	Agriculture, Livestock	8%	Cost of replacement, review of main soils and farms types
Malawi, 1992	Agriculture	3%	Modelling of soil losses related to decrease in productivity

**AGDP: Agricultural Gross Domestic Product*

The diversity of methods in use somehow shows a relative homogeneity in results. To summarize, the loss of ecosystem services on production appears costly to societies, even though it may appear below 10% of the Agricultural Gross Domestic Product (AGDP) or 1.4% of the GDP.

For countries in sub-Saharan Africa, the losses range between 1-10% of AGDP. Considering the importance of agriculture in the national Gross Domestic Product of these countries, ecosystem services remain a strong development issue in Africa. As a matter of fact, the annual cost of land degradation in sub-Saharan Africa is equivalent to the region's mean agricultural growth. Hence the question of whether there is any actual rural development in these countries.

The few results to be found in the literature regarding production services are then very telling, even though they are probably underestimated: for a majority of sub-Saharan studies, only agricultural losses are estimated, while breeding costs which contribute a greater portion of AGDP of these countries, are ignored.

Globally, these methods do not take into account the multiple uses to which a space may be put. Thus, it is critical and interesting to consider these limits, especially in connection with the ecosystem services concept and approach:

- They address mainly provisioning and supporting ecosystem services ;
- They do not include regulation services, nor cultural services;
- The choice of the period of reference for calculation (length and dates) plays a role on the annual cost that is finally obtained;
- Most of them rely on scaling up the results obtained from field and micro-studies: there is still a strong scientific challenge to be addressed on the issue of how up-scaling of micro-data and micro-models at national level represent macro-level reality;
- They do not consider the cumulative process of erosion within modelling; and,
- The focus is on agriculture, but the diversity of agricultural systems is forgotten.

Also, most of these valuations only take into account the direct effects of desertification. Nevertheless, indirect costs such as damages to infrastructure or to global equilibriums (silting up of downstream reservoirs, the impact of dust storms etc.) are to be far above direct costs of ecosystem services degradation; hence, underestimation of the calculated costs.

2. Ecosystem Services Valuation: Some Knowledge Gaps

Sustainable land management practices consist of implementing biological and mechanical soil and water conservation (SWC) actions that will allow not only the increase of provisioning services, but will also better support ecosystem services.

The benefits of these good practices can also be valued and compared to their cost so as to find out the economic rate of return (ERR). Reij and Steeds' (2003) synthesis on success stories in African drylands have provided a calculation of ERR between 10-30% for several projects to properly tackle land degradation. Some of the current methods used to assess the benefits are presented in Table 2.

Table 2. Possible ways to value various soil and water conservation (SWC) benefits.

Types of benefits	**Indicators**	**Possible measurements**
Increase of available agricultural products	Variation in agricultural production	Variations in yields x local and or global prices
Increase of available fodder and livestock capacity	Variation in livestock/fodder production	Variations in livestock carrying capacity x local/global prices Variations in fodder yields x local/global prices
Reforestation	Variation in forest cover	Variations in volumes of woodland non-ligneous products x local/global prices
Increase in available water	Replenishment of water tables	Variation in water carrying time x average cost of labour Volume x value of water recovered
Recovery of biodiversity (soil included)	Modification of landscapes, habitats, species, and fauna, etc.	Contingent valuation For species recovered in private gardens: Surface areas or amounts concerned x local/global prices of species recovered
Mitigation of climate change	Storage of carbon	Quantities of carbon stored x market price of carbon

These benefits are based on the economic value of the increased production allowed by the soil and water conservation (SWC) techniques implementation. At that stage, ecosystem services valuation shows various knowledge gaps. There is still inadequate understanding of how to value regulation services from an economic perspective.

Moreover, a specific action may result in negative impacts on ecosystem services depending on types of services under consideration. For example, planting eucalyptus will provide firewood and raw material for papermaking, thus provisioning services. Eucalyptus is a water-demanding species, and also has a negative influence on biodiversity by limiting above-ground vegetative growth that develops under the trees and shrubs. Removing local trees and vegetation to plant eucalyptus may negatively influence water availability and eventually induce erosion, which will affect ecosystem regulatory and support services. Such effects depend entirely on the characteristics of the land and climate where the eucalypti are to be planted.

This example shows mainly that encouraging the development of provisioning ecosystems services through specific actions and projects without considering the impacts on the other ecosystem services, specifically regulation services, can aggravate the overall ecosystem services deterioration in the medium or long term.

The classification of ecosystem services, though intellectually understandable, proves also to be difficult to implement when testing the existing valuation methods, particularly the fact that specialists have not yet agreed on the use of a single method that would settle the above-mentioned difficulties (see Figure 2).

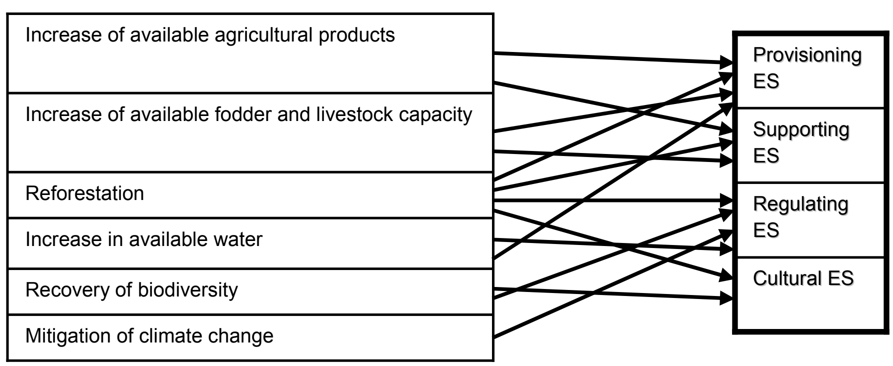

Figure 2. Measuring ecosystem services through specific actions.

Figure 2, though not yet completed, shows how several actions for improving the supply of ecosystems complicate the economic valuation of their benefits. For instance, reforestation on its own summarizes the whole complexity of how to give an economic value to improvement of ecosystem services.

3. Environmental Services: Institutional Framework

Provisioning and regulating ecosystem services are interlinked. It is well known that enhancing provisioning services can affect regulation services. In Western Europe, agricultural development based on intensification resulted in polluting groundwater and rivers, and affecting biodiversity. Whence, the challenge is how to build institutional systems and incentives for individuals to provide regulation services through their day-to-day use of ecosystems as production service suppliers?

The approach on the multi-functioning of territories relies more on the notion of environmental service (Figure 3): an environmental service is indirectly induced by a producer performing its current activities. This service will benefit all users, creating a win-win situation.

From the above discussions, two economic understandings can be derived:

- Environmental service as a positive externality.
- Environmental service as a public good.

For example, public reforestation will allow forest products such as mushrooms to be collected or recreational walking for users. At an individual level, this scheme works well for farmers. On the other hand, some agricultural techniques rely on the establishment of close-set hedge results by improving biodiversity that provides shelter to birds and allowing the development of diverse plants, which ultimately contributes to the aesthetic beauty of the landscape.

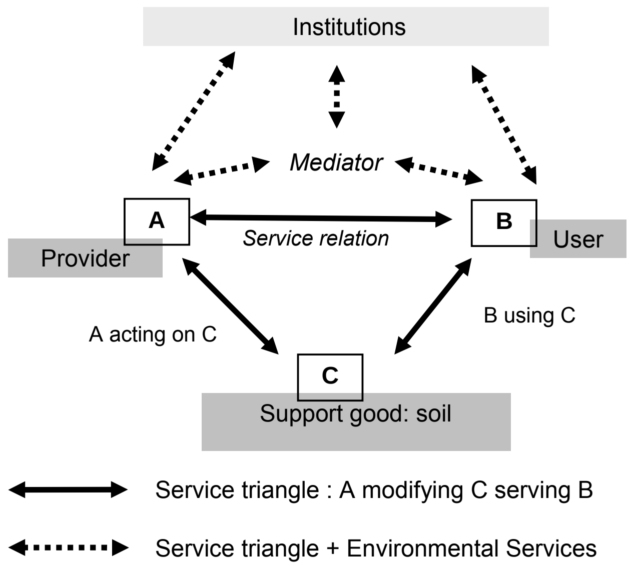

Figure 3. Institutions as mediators for fostering and rationalizing provisioning environmental services. Source: Gadrey, 1996; Aznar and Perrier-Cornet, 2002.

Environmental service results in improving ecosystem services. In order to enhance environmental service provisioning, economists encourage institutions to set up concrete incentives to encourage producers to contribute to ecosystem services when designing and developing their agricultural production activities.

Conclusion

The economics of ecosystem services *per se* is a challenge due to the fact that the understanding provided by the notion of ecosystem services does not always correspond to the economic way of thinking for nature or natural capital. Presently, much improvement has been achieved on economic valuation of natural capital in the last twenty years. More concretely, from the ecosystem services perspective:

- Provisioning services are generally estimated: the examples of land degradation in Africa give an explicit view of such valuations, which are useful to assess the cost of land degradation to rural development in developing countries.

- Valuation of benefits of action to restore ecosystem functioning, though partially, is also useful to foster and help estimate the economic investment in fighting land degradation. As a matter of fact, in deprived African drylands, most farmers have no means to finance such investments.

- Lastly, some economic analyses rely on spatial or territory notions together with the multi-functioning of space. However, could multi-functioning be interpreted in terms of ecosystems services? It seems that there is no consensual framework on a typology of “socio-ecosystems” that describes ecosystems in relation to their uses, impacts and interrelations. In most cases, the economists do not use this terminology. Nevertheless, ecosystem services would also lay claim to such an approach.

References

Aznar O. and P. Perrier-Cornet, 2002. *Les services environnementaux : diversité des conceptions et réalité des contours*. Colloque SFER, Multifonctionnalité, Paris, INAPG, 21-22 mars 2002, pp. 21.

Berry Leonard and Jennifer Olson, 2003. *Land Degradation in Rwanda: Its Extent and Impact*. Florida Center for Environmental Studies, Paper Commissioned by the Global Mechanism with support from the World Bank, pp. 18.

Bojö J., 1996. “The Costs of Land Degradation in Sub-Saharan Africa” in *Ecological Economics* 16, pp. 161-173

Dregne, H. E. and N.T. Chou, 1992. “Global Desertification: Dimensions and Costs” in *Degradation and Restoration of Arid Lands*. Lubbock, Texas Tech. University.

Gadrey J., 1996. *Services : la productivité en question.* Desclées de Brouwer, Paris, pp. 359.

Hassan, R., R. Scholes and N. Ash, 2005. *Millennium Ecosystem Assessment: Ecosystems and Human Well-being* Island Press, Washington, D.C.

République Algérienne Démocratique et Populaire, 2002. *Plan National d’Action pour l’Environnement et le Développement Durable (PNAE-DD)*. METAP, pp. 148. Available at: http://www.metap.org/.

République Tunisienne, 2003. *Evaluation de Coût de la Dégradation de l’Environnement*. Rapport METAP, Banque Mondiale. Available at: http://www.metap.org/.

Royaume du Maroc, 2003. *Evaluation du coût de la dégradation de l’environnement, 01*. Rapport METAP, Banque Mondiale. Available at: http://www.metap.org/.

Paggiola S., K. Von Ritter and J. Bishop, 2004. *Assessing the Economic Value of Ecosystem Conservation.* Environment Department Paper n° 101, The World Bank in collaboration with IUCN.

Reij, C., and D. Steeds, 2003. *Success Stories in Africa’s Drylands: Supporting Advocates and Answering Sceptics*. Paper commissioned by the Global Mechanism of the Convention to Combat Desertification, pp. 32.

Requier-Desjardins M., 2007. “Why We Should Invest in Arid Areas” in *Les Dossiers thématiques du CSFD*, n°5. CSFD/Agropolis International, Montpellier, France, pp. 44.

World Bank, 2002. *Arab Republic of Egypt Cost Assessment of Environmental Degradation.* METAP, pp. 19.

World Bank, 2006. *Where is the Wealth of Nations? Measuring Capital for the 21st Century*. The World Bank, pp. 188.

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Session 3:
Mitigating Climate Change through Restoration of Degraded Land

Soil Carbon Sequestration through Desertification Control

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Abstract

Desertification, a natural process, is exacerbated by anthropogenic activities. It reduces soil productivity, jeopardizes food security, impairs environment quality, accelerates global warming and exacerbates global security risks. Degradation of soil and vegetation aggravates the emission of greenhouse gases into the atmosphere. The biophysical processes of soil and vegetation degradation are closely interlinked by social, economic and political factors which govern land ethics and are prone to the tragedy of the commons. The annual rate of global emissions has increased from 1.3%/yr in the 1990s to 3.3%/yr for 2000-2006, with dire consequences to global warming and environment quality. While global emissions must be reduced by 2030 through a range of options, by 100 billion tonnes (Pg) to stabilize atmospheric abundance at 650 ppm of CO_2 eq., and by 250 Pg at 490-540 ppm of CO_2 eq., there exists an opportunity to utilize C sink capacity of the degraded and desertified terrestrial biosphere. Desertification control and restoration of degraded soils and ecosystems has a potential to sequester 0.9-1.9 Pg C/yr. However, conversion to a restorative land use and adoption of recommended management practices remain a challenge for the resource-poor farmers and small land holders of the regions prone to desertification. Thus, creating another income stream through the trading of C credits may provide the much needed financial support to invest in land restoration.

Introduction

Anthropogenic emissions between 1850 and 2006 are estimated at ~ 330 Pg C due to fossil fuel combustion and cement manufacture, and an additional 158 Pg from land use change and soil cultivation. Furthermore, the emissions due to fossil fuel combustion have increased from 7.0 Pg/yr in 2000 to 8.4 Pg/yr in 2006 (Canadell et al., 2007). The average growth rate of emissions due to fossil fuel combustion and cement manufacture have increased from 1.3%/yr in the 1990s to 3.3%/yr for 2000-2006. Consequently, the atmospheric concentration of CO_2 in 2006 of 381 ppm is the highest since several million years (Canadell et al., 2007). Total anthropogenic emissions are estimated at 7.0 Pg C/yr for 1970-1999, 8.0 Pg C/yr for 1990-1999, and 9.1 Pg C/yr for 2000-2006. For the same periods, the atmosphere has absorbed 3.1 Pg/yr, 3.2 Pg/yr and 4.1 Pg/yr, respectively. The capacity of the natural sinks (e.g., land, ocean) was 56.3% for 1970-1999, 60.0% for 1990-1999 and 54.9% for 2000-2006 (Table 1). The capacity of land sink alone for the same period was 28.1%, 27.2% and 24.2%, respectively. Thus, the capacity of land sink has progressively declined, probably due to an increase in the extent and severity of desertification and degradation of world soils and ecosystems.

Table 1. Recent trends in the global carbon budget (Recalculated from Canadell et al., 2007).

Parameter	1970-1999	1990-1999	2000-2006
I. Sources (Pg C/yr)			
Fossil fuel combustion	5.6	6.5	7.6
Land use change	1.5	1.6	1.5
Total	7.1	8.1	9.1
II. Sinks (Pg C/yr)			
Atmosphere	3.1	3.2	4.1
Ocean	2.0	2.2	2.2
Land	2.0	2.7	2.8
Total	7.1	8.1	9.1
Capacity of All Natural Sink (%)	56.3	60.0	54.9
Capacity of Land Sink (%)	28.2	27.2	24.2

Desertification and the degradation of soil and vegetation in drylands impacts about 1 billion people worldwide in more than 100 countries (Doolittle, 1997). It leads to a decline in soil and environment quality and perpetuates the food deficit (Lu, 2001). Of the 6.31 billion hectares (Bha) of the world's dryland area, 5.17 Bha or 69% is presumably desertified to some degree through degradation of either vegetation, soil or both (UNEP, 1991; 1992). Of the desertified land area, 1.016 Bha is desertified cropland and rangeland and 2.57 Bha of degraded vegetation in the rangeland. In comparison, Oldeman and Van Lynden (1998) estimated that the area affected by desertification is 1.137 Bha. Of this, 0.489 Bha is severely/extremely desertified. Similar to the estimates of land area affected by desertification, those of the rate of desertification also vary widely. The annual rate of desertification is estimated at 5.83 million hectare (Mha) or 0.132%/yr of the world's drylands (UNEP, 1991; Mainguet, 1991). Even if these statistics are nearly correct, it is hard to understand the reasons for a nearly lack of concrete action by the global community.

Some consider that the process of desertification is set in motion by the "tragedy of the global commons" (Hardin, 1968). It is the overgrazing of the common rangelands and indiscriminate deforestation of the common woodlots which lead to the mining of soil fertility, depletion of the soil carbon pool, and over-exploitation of the groundwater leading to denudation of the vegetation cover, acceleration of soil erosion by water and wind, and increase in the frequency and intensity of dust storms. As Aristotle said, "What is common to the greatest number gets the least amount of care. Men pay most attention to what is their own: they care less of what is common". Indeed, desertification is a biophysical process of aridization of a region, but it is driven by a strong interaction between natural resources (e.g., soil, vegetation, water, climate) with socio-economic and political factors. The principal cause of desertification, land misuse and soil mismanagement leads to a progressive decline in soil quality, a breakdown of structural properties, an increase in susceptibility to crusting and compaction, an increase in losses of water by surface run-off and evaporation, acceleration of soil erosion by water and wind, depletion of plant nutrients and soil organic matter (SOM), and the overall decrease in the net primary productivity (NPP).

One of the consequences of the process of desertification is the loss of soil carbon (C) pool, some of which is emitted to the atmosphere as carbon dioxide (CO_2) (Lal, 2001; 2003). The soil C pool, comprising soil organic C (SOC) and soil inorganic C (SIC), is highly dynamic and can be a source of atmospheric CO_2 under the conditions of inappropriate land use and soil mismanagement ($C_{output} > C_{input}$). Therefore, desertified soils have a much lower SOC pool than the undegraded soils under the protective cover of the natural vegetation. Thus, restoration of degraded/desertified soils can reverse the process and lead to an increase in the soil C pool along with replenishment of soil fertility and an increase in activity and species diversity of soil fauna and flora (Lal, 2001).

Comparing the 1990s with 2000-2006, the emission growth rate of CO_2 has increased from 1.3% to 3.3%/yr because of the growth in the world economy and its C intensity (Canadell et al., 2007). There is also a long-term increase in the airborne fraction of the CO_2 emissions, an indication of the decline in the efficiency of the natural CO_2 sink of land and ocean (see Table 1). With the current and future threat of global warming, there is a strong interest in developing cost-effective and efficient strategies of sequestering atmospheric CO_2 with ancillary benefits. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has estimated that the cumulative emission reduction needed between 2000 and 2030 is 100 Pg to stabilize the atmospheric abundance of CO_2 at 650 ppm of CO_2-eq, and 250 Pg to stabilize at 490-540 ppm CO_2-eq (Bohannon, 2007). The strategies identified to reduce these emissions include the following: cuts in greenhouse gases other than CO_2, emission capture and storage, energy conservation and efficiency, renewable energy including nuclear and biofuels, and C sequestration in terrestrial sinks including the terrestrial biosphere. Therefore, the objective of this paper is to describe factors affecting desertification and assess the potential of desertification control and restoring degraded soils and ecosystems to sequester C and mitigate global warming.

1. Global Warming and Desertification

There is a close link between global warming and desertification. The process of desertification is likely to be exacerbated by the current and projected global warming. The historical evolution of human awareness about the impact of the atmosphere on the earth's climate has been vividly explained by Weart (2003), and is briefly summarized here. The process of global warming has been recognized since 1783, when a volcanic fissure in Iceland erupted, pouring out several km^3 of lava in the atmosphere. A peculiar haze dimmed the sunlight over Western Europe for months. During his visit to Europe in 1783, Benjamin Franklin noticed the unusual cold that summer and speculated that it might have been caused by the volcanic fog (Weart, 2003). The energy budget of Earth's atmosphere was first estimated by Joseph Fourier in the 1830s. He argued that the sun's radiation is balanced by the invisible infrared radiation emitted by the earth, and that the earth's atmosphere somehow keeps some of the radiation in. John Tyndall (1862) observed that some of the trace gases in the atmosphere (CO_2, CH_4, H_2O vapour) were opaque to infrared radiation while O_2 and N_2 were not (Weart, 2003). Tyndall argued that these trace gases in the atmosphere have the same effect as does the glass in the greenhouse, and thus named these as "greenhouse gases". John Tyndall argued that the atmosphere acts as a barrier to outgoing radiation and raises temperature at the Earth's surface (Tyndall,1863). Swante Arrhenius (1896) and his colleague Arvid Högbom (1897) estimated that doubling the CO_2 concentration in the atmosphere would raise the earth's temperature by 5-6 °C (Weart, 2003). It was Högbom who estimated that the temperature in the Arctic regions would rise about 8-9°C if the carbonic acid increased 2.5-3 times. Alfred Wallace, in his book *Man's Place in the Universe* made two important observations: (i) the atmosphere (areal ocean) allows sun rays to pass but its constituents (water vapour and carbonic acid) intercept and absorb the sun's radiation; and (2) an increase in Earth's temperature may cause some extremely violent and intense storms to uproot even the largest of trees (Wallace,1903). The second observation is extremely relevant to Hurricane Katrina that hit New Orleans, USA in 2005 and Cyclone Sidr that hit Bangladesh in 2007. In his lecture to the Royal Metropolitan Society, Guy Stewart Callender (1938) hypothesized that carbon dioxide produced by industry is responsible for global warming. *Time Magazine* carried a lead article entitled the "Warmer World" in its 2 January 1939 issue which stated that "Gaffers who claim that winters were harder when they were boys were quite right" (Time, 1939: 27). The theme reappeared in the 26 March 2006 issue of *Time Magazine* with a lead article entitled "The Tipping Point" which stated that "Polar ice caps are melting faster than ever…More and more land is being devastated by drought…Rising waters are drowning low lying communities…By any measure, Earth is at the Tipping Point" (Kruger, 2006). The dynamic nature of Earth's climate has influenced the evolution of human and other biota on earth (Linden, 2006). Climate change can change civilization and human history (Fagan, 2004).

While the greenhouse effect is a natural process, essential to life on earth, it is the acceleration of the natural process by anthropogenic activities that leads to the so-called 'global warming'. The rate of increase in temperature by global warming is >0.1 °C/decade, so that the ecosystems cannot adjust to this rapid change. For each 1° C increase in global temperatures, the vegetation zones may move pole-ward by 200-300 km. The global warming observed since the middle of the 20th century, estimated at an increase of earth's mean temperature by 0.6 ± 0.2 °C and a sea level rise of about 18 cm, is attributed to an increase in atmospheric abundance of trace gases (CO_2, CH_4, N_2O) since the Industrial Revolution occurred around 1750 (IPCC, 2001; 2007). While the principal source of anthropogenic emission is fossil fuel combustion, the impact of land use and land use change and of soil cultivation on the emission of trace gases in the atmosphere cannot be overemphasized. Ruddiman (2003; 2005) argues that a trend of increase in atmospheric concentration of CO_2 began 8000 years ago, and that in the case of CH_4 emission 5000 years ago, corresponding with the dawn of settled agriculture with attendant deforestation, soil cultivation and the spread of rice paddies and raising of cattle. Ruddiman (2003) estimates the pre-industrial emissions at 320 Pg primarily from terrestrial sources (biota and soil) caused by deforestation, land use change and soil cultivation. By comparison, emissions from land use change are estimated at 136 Pg between 1850 and 2000 (IPCC, 2000), and 158 Pg between 1850 and 2006 (Canadell et al., 2007). In contrast, emissions from world soils caused by ploughing and tillage are estimated at 78 ± 12 Pg (Lal, 1999). It is the depletion of the SOC pool that has created the C sink capacity in world soils because most cultivated/agricultural soils contain much less SOC pool than their potential capacity. The magnitude of depletion of SOC pool from agricultural soil is exacerbated by soil degradative processes (e.g., erosion, salinization, physical and chemical degradation). Furthermore, depletion of the SOC pool leads to declines in soil quality and the ecosystem services it provides (Lal, 2004).

2. Carbon Sequestration in World Soils and Terrestrial Ecosystems

Carbon sequestration involves the capture and secure storage of atmospheric C that would otherwise be emitted or remain in the atmosphere. Carbon sequestration is important because: (i) as of yet, there are no non-carbon fuel sources as viable alternatives to fossil fuels; (ii) there is a need to stabilize atmospheric abundance of CO_2; (iii) it is necessary to restore ecosystem services of degraded soils/ecosystems; and (iv) there is an urgency to advance/achieve global food security. It is in this regard that identification of an appropriate C sink (e.g., geologic, oceanic or terrestrial) is important. Choice of an appropriate sink and of a C sequestration strategy depends on numerous characteristics including the following: (i) high sink capacity; (ii) long residence time or stability of the sink; (iii) low cost of C sequestration; (iv) either a positive or minimal negative environmental impact; and (v) numerous ancillary benefits.

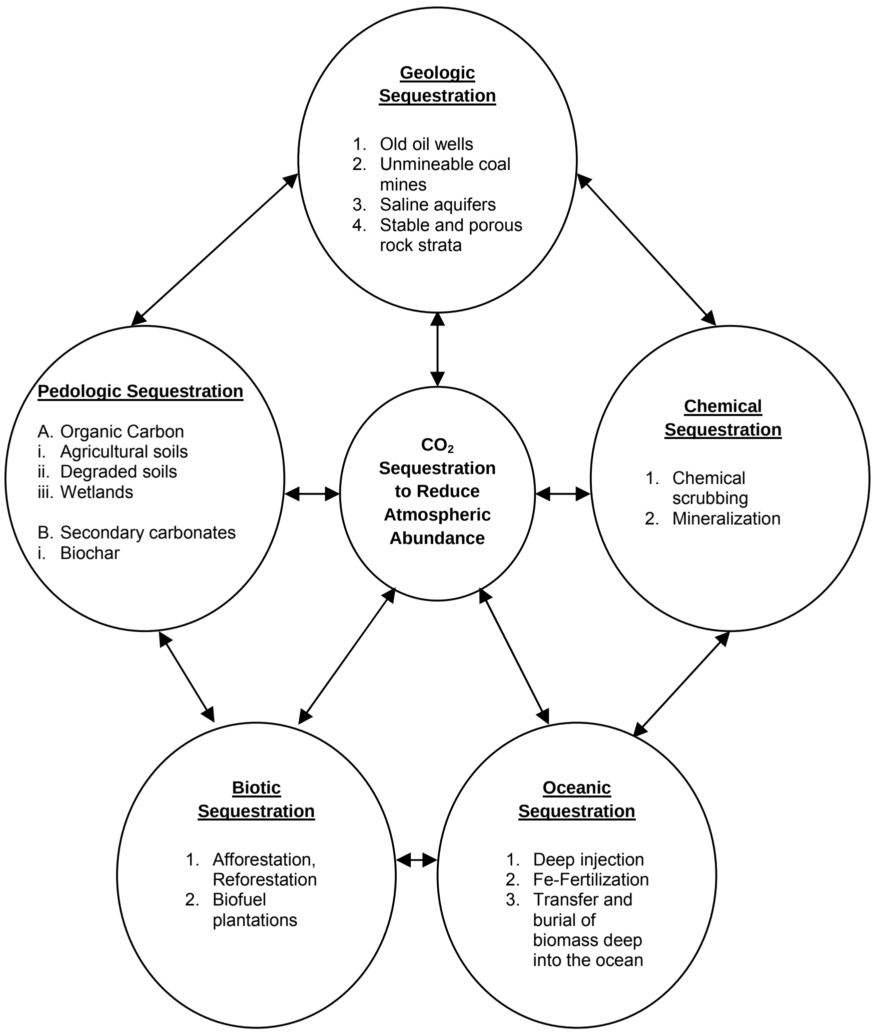

Figure 1. Sequestering atmospheric CO_2 into long-lived Carbon pools (sinks).

Figure 1 outlines numerous potential C sinks and strategies to transfer atmospheric CO_2 into these sinks. There are pros and cons for each strategy (Socolow, 2005; Lal, 2008). Geologic sequestration involves the capture, purification, compression and transport of industrial CO_2 into stable geologic strata 2000-3000 m below the soil surface. Traditionally, injection of liquefied CO_2 into old oil wells is recommended to enhance oil recovery (EOR) and old coal seams to enhance coal bed methane (CBM). Geologic sequestration also involves the injection of liquefied industrial CO_2 into stable rock strata and in saline aquifers where it may be converted into stable minerals. The chemical sequestration involves chemical scrubbing of industrial CO_2 and its mineralization or conversion into carbonates of calcium (Ca) and other metals. Similar to geologic sequestration, oceanic sequestration involves the injection of industrial CO_2 into the ocean several metres below the surface (Lal, 2008). In addition to injection, oceanic sequestration also involves the use of iron (Fe) fertilization to enhance biomass production and conversion of atmospheric CO_2 into biomass by enhancing the growth of oceanic biota. Some have argued that burying biomass (crop and forest residues) deep into the ocean can also sequester C because of no microbial decomposition. Both geologic and oceanic sequestration strategies have high sink capacity. However, these strategies are expensive, have some adverse environmental impacts, and the stability of these sinks is questionable. Thus, measurement and verification are necessary to validate that there is no leakage.

In contrast to the engineering techniques of geologic and oceanic sequestration, biotic sequestration is a natural process. It is based on the natural process of photosynthesizing atmospheric CO_2 into carbohydrates, cellulose, lignin and eventually into humic substances. Annually, about 120 Pg of CO_2-C is converted into biomass by the photosynthetic process. However, most of it is returned back into the atmosphere either by plant respiration (60 Pg) or by soil respiration (60 Pg). The rationale for emphasizing the biotic over the engineering strategies (e.g., geologic and oceanic) of C sequestration lies in the concept that if even 7% of the 120 Pg of naturally photosynthesized C can be retained in the biosphere, it can effectively offset the current level of industrial emissions estimated at 7.6 Pg C/yr during 2000s (WMO, 2006; Canadell et al., 2007).

There are several components of terrestrial/biotic sequestration (Figure 2). Important among these are: (i) forest biomass both above and below ground; (ii) wetlands; (iii) bioenergy plantations; and (iv) soil/pedologic C pool. Important strategies of soil/pedologic sequestration are the conversion of biomass-C into stable humic substances and organic-mineral completes or into secondary carbonates in agricultural soils, degraded soils and wetlands.

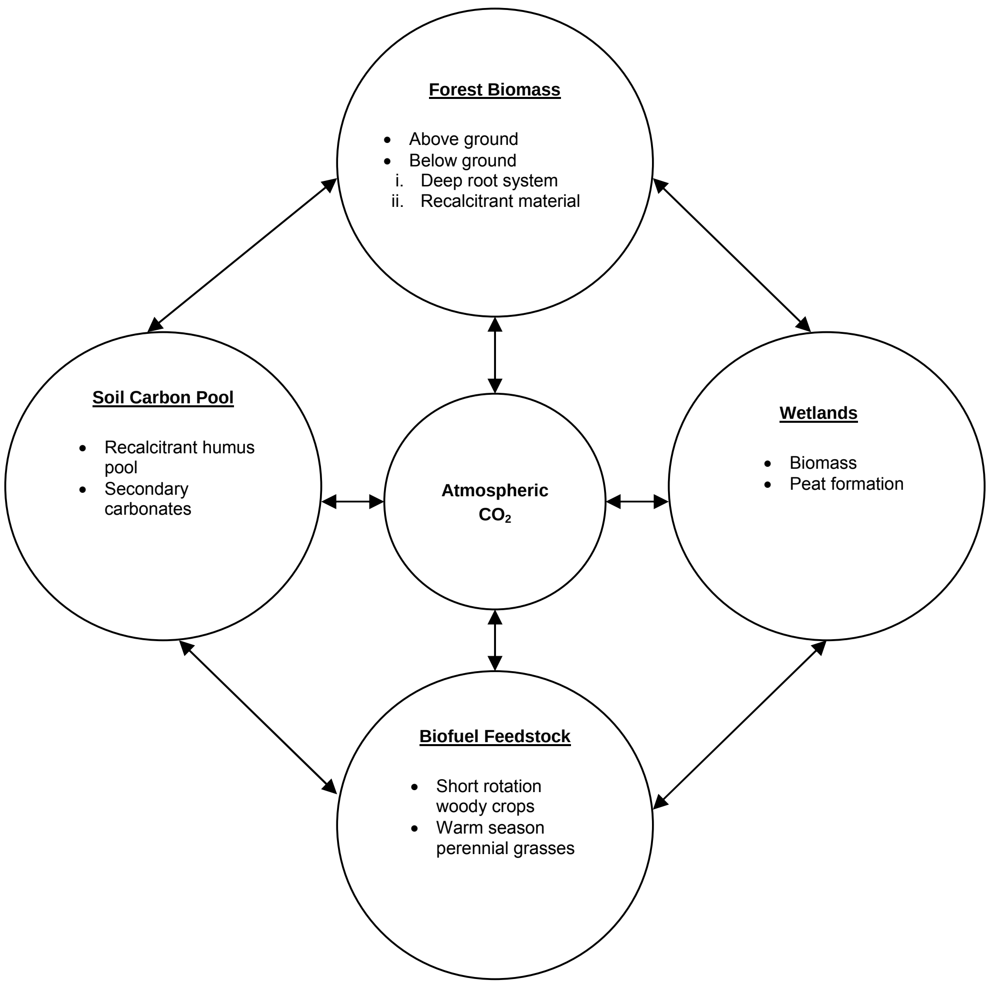

Figure 2. Strategies of terrestrial carbon sequestration in biota and soil.

Some promising techniques of C sequestration into the terrestrial biosphere are outlined in Figure 3. Recommended management practices for soil C sequestration include: (i) erosion control and restoration of degraded/desertified soils; (ii) conservation/no-tillage in association with the use of crop residue mulch and incorporation of cover crop in the rotation cycle; (iii) use of manure and techniques of integrated nutrient management; (iv) adoption of agro-forestry and diversified/complex farming/cropping systems; and (v) improving pastures and using controlled grazing. Establishing biofuel plantations or the afforestation of marginal soils is a viable strategy for C sequestration in terrestrial ecosystems.

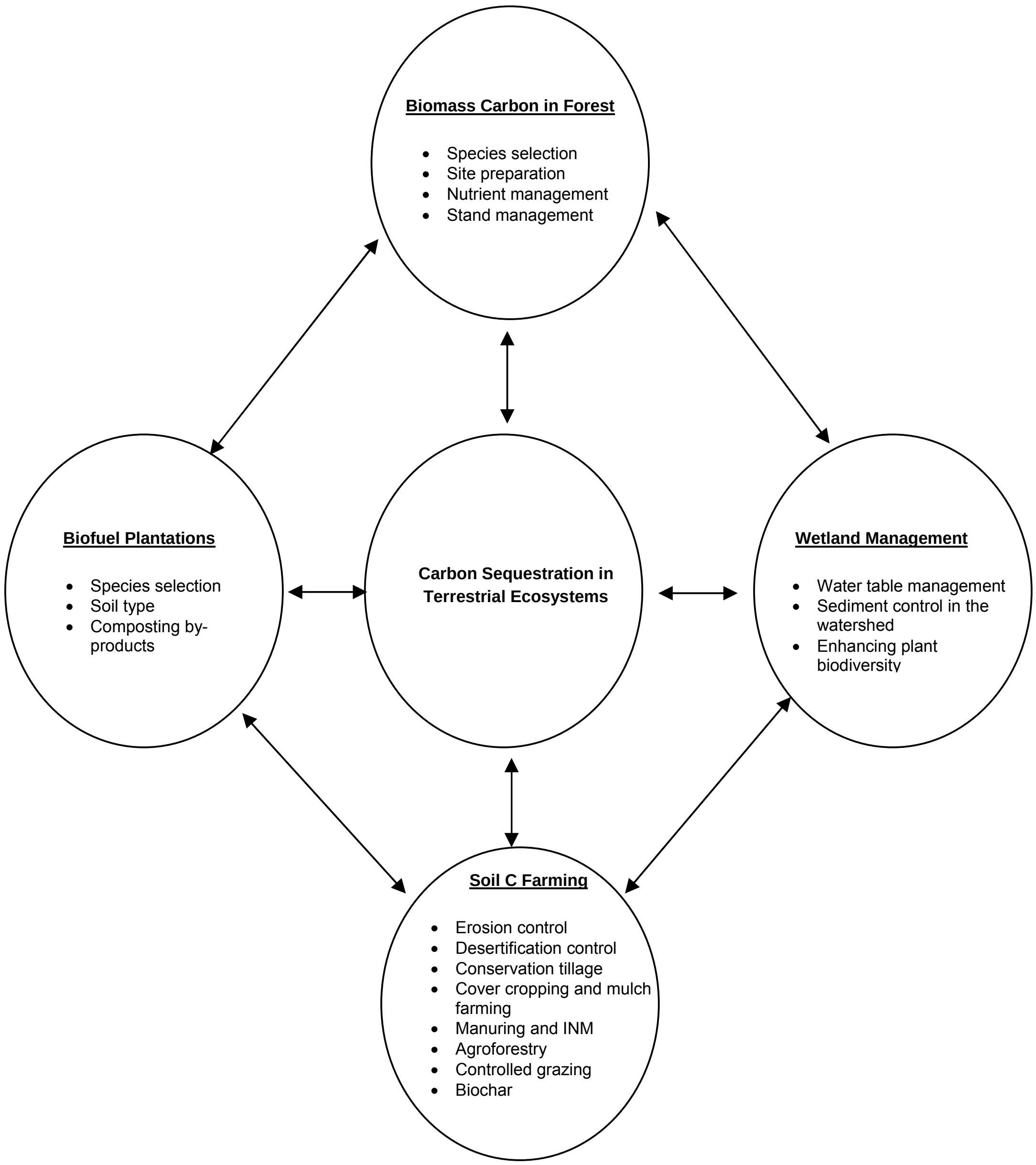

Figure 3. Technological options for carbon sequestration in terrestrial ecosystems.

Enhancing SOC pool has numerous ancillary benefits, especially with regards to the following: (i) improvement of soil structure and tilth; (ii) reduction in soil erosion hazard; (iii) increase in plant available water; (iv) improvement in plant nutrient reserves and recycling; (v) increase in availability of food for soil biota; (vi) purification and filtration of water; (vii) increase in biodiversity; (vii) improvement in crop/biomass yields; and (ix) offset of fossil fuel emissions with a positive impact on the mitigation of global warming. Above all, soil C sequestration is a cost-effective and natural process. It makes soil a living system. The importance of managing and sustaining SOC pool to enhancing soil quality and sustaining agronomic/biomass productivity has been recognized for centuries if not millennia (Thaer, 1809, 1811; King, 1911, 1926; Semple, 1928; Albrecht, 1938; Howard, 1940, 1952; Jenny, 1941; Allison, 1973; Feller, 1997).

3. Nutrient and Water Requirements for Carbon Sequestration in Soil and Terrestrial Ecosystems

The CO_2 from the atmosphere is just one component converted into carbohydrates, just as carbon in the biomass is only one of the essential building blocks of humus. Other essential components for converting CO_2 into biomass are water and plant nutrients for photosynthesis, and nitrogen (N), phosphorus (P) and sulphur (S) and other elements for converting biomass into humus. Water and essential nutrients/elements are in short supply, especially in deserts and desertified ecosystems, and are a major constraint to enhancing terrestrial C sequestration in these regions. For example, C:N, C:P and C:S ratio is 80-100, 200-400 and 300-600, respectively, in the biomass versus 10-14, 40-60 and 60-80 in the humus. Thus, an additional supply of N, P, S and other elements is essential to converting biomass C into stable humic substances. Himes

(1998) calculated that sequestration of 10 Mg of C into humus would require 28 Mg C contained in 62 Mg of oven dry crop residues, 833 kg N, 200 kg P and 142 kg S. Availability of these elements would produce about 17.3 Mg of humus leading to an increase of SOC concentration by 0.7% in the 20 cm soil layer. Lal (2004) estimated that agricultural soils have a potential to sequester 0.6-1.2 Pg C/yr. Requirements for the realization of this potential include 3.7-7.4 Pg of oven dry biomass, 0.05-0.1 Pg N, 0.012-0.024 Pg of P and 0.0086-0.0172 Pg of S. The total amount of humus thus created (1.0-2.1 Pg) would offset atmospheric CO_2 by 0.28-0.56 ppm. It is important to realize that a positive soil nutrient budget is essential to enhancing SOC pool (and plant nutrients) while growing biomass is a major constraint that must also be addressed.

Regions with a high potential of sequestration in soils and terrestrial ecosystems are those which have depleted/degraded soils and denuded vegetation cover. There are large areas of sub-Saharan Africa (SSA) and South Asia (SA) where the SOC pool has been mined out by land misuse and soil mismanagement. Henao and Baanante (2006) estimate that in SSA, depletion rates of nutrients range from 30-40 kg to 60 kg of NPK/ha/yr. The International Fertilizer Development Center (IFDC) (2006) estimates that about 95 Mha of arable land in Africa have reached such a state of degradation that only huge investments could make them productive again. Restoration of these degraded soils and ecosystems would enhance the terrestrial C pool, improve ecosystem services, offset fossil fuel emissions, and advance the much needed food security while breaking the perpetual agrarian stagnation.

4. Removing Crop Residue for Biofuel Production

In an attempt to produce C-neutral fuel, crop residues are being considered as a source of ligno-cellulosic biomass (Somerville, 2006; Kennedy, 2007). However, crop residues and other bio-solids produced from agro-ecosystems have numerous competing uses (e.g., soil amendment, feed, industrial raw material, construction material and fuel). Removal of crop residues for uses other than as soil amendment can adversely affect soil quality and disrupt numerous ecosystem services (Wilhelm et al., 2004; Blanco-Canqui and Lal, 2007). Indiscriminate harvest of crop residues amounts to robbing Peter to pay Paul (Lal and Pimentel, 2007), and has severe environmental consequences especially with regards to accelerated erosion (Pimentel and Lal, 2007). The environmental costs and those related to a decline in agronomic productivity are large and appropriate to support the argument that "there is no such thing as a free biofuel from crop residues" (Lal, 2007). Doornbusch and Steenblik (2007) argue that biofuel as a cure is worse than the disease. Indeed, there are numerous adverse impacts of harvesting crop residues on soil quality (Figure 4). Residue removal adversely impacts soil's physical, chemical and biological quality. The latter is jeopardized because residues provide food substrates for soil biota. To live, an organism must have a source of energy. Soil organisms, essential to maintaining their quality, also need food. The latter comes from returning biomass/crop residues to the soils.

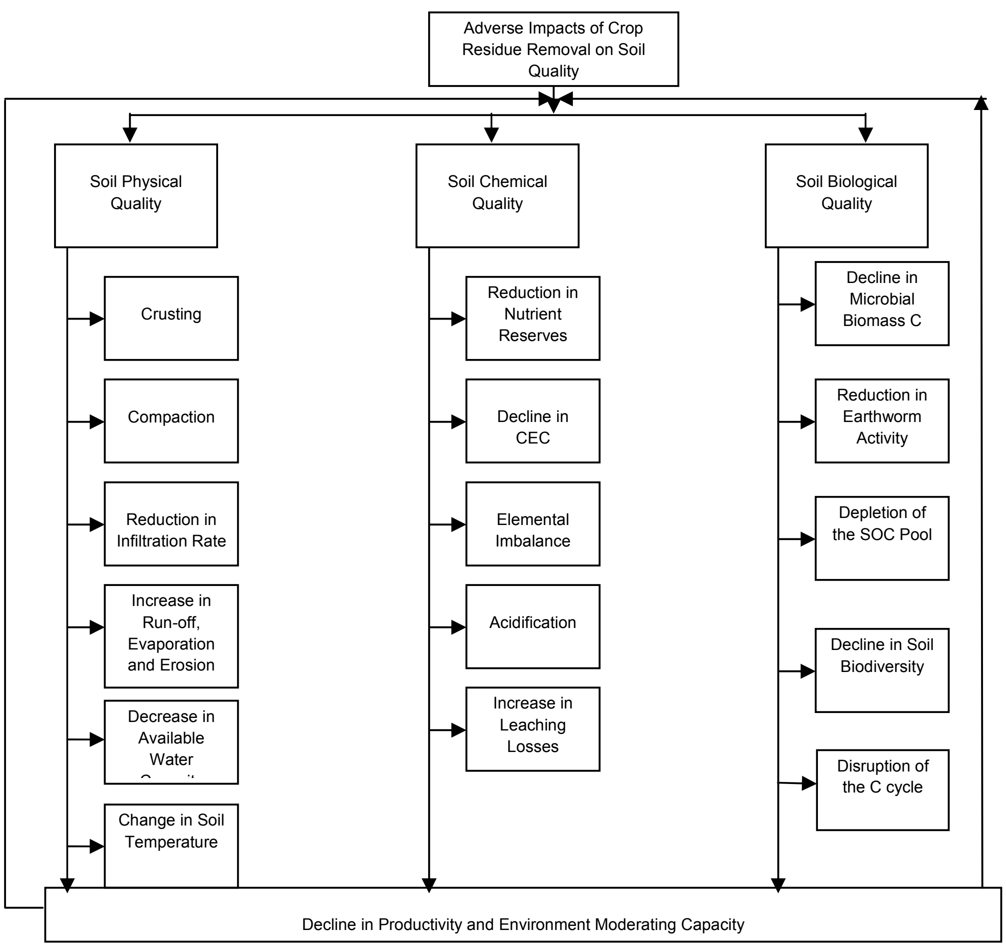

Figure 4. Adverse impacts of harvesting crop residues on soil and environment quality.

5. The Land Ethic

The severe problems of soil degradation and desertification, driven by socio-economic and political forces, require the establishment of land ethics and a strong need for promoting stewardship of soil resources. As Leopold (1981) states "there is as yet no ethic dealing with man's relationship to land and to animals and plants which grow upon it. Land, like Odysseus' slave girls, is still property: the land relation is still strictly economic, entailing principles but not obligation" (Leopold, 1981: 218). Human society has learned some critical lessons and has developed a collective wisdom that can guide us to sustainable management of soil resources. We do now recognize that the environmental issues are really problems affecting all of humanity. For example, exhaust fumes and soot from traditional cooking fuels can cause respiratory diseases, fossil fuel emissions lead to global warming, acid rain kills trees and fish, deforestation causes flooding and land slides, chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) deleteriously impact the ozone layer, and mono-cropping reduces biodiversity. Indeed, there is a price attached to all the goods and services provided by earth's resources. The choice of any strategy reflects the value that humans place on the benefits yielded by a given technological advance and the harm associated with the hazard. Therefore, it is prudent to carefully balance the benefits versus the hazards to objectively assess the ecological footprints and not just the economic value. It is important to science to address the commons. Identifying technological responses to alleviate these problems and rewarding those who no longer desecrate these commons is a prudent strategy. It is urgent to identify and implement the corrective feedbacks that are needed to keep custodians honest by creating environmental monitoring systems and taking responsibility for maintaining, controlling and disseminating the information among all stakeholders. As Adlai Stevenson (1965) states "we travel together like passengers on a little spaceship, dependent on its vulnerable reserves of air and soil; all committed for our safety, to its security and peace, preserved from annihilation only by care, the work, and, I will say, the love we give our fragile craft". As an ancient Vedic scripture states: "upon this handful of soil our survival depends. Husband it and it will grow our food, our fuel and our shelter and surround us with beauty. Abuse it and soil will collapse and die, taking humanity with it".

6. Offsetting Fossil Fuel Emissions through Desertification Control and Reclamation of Desertified Soils and Ecosystems

Desertification control involves the removal of the causes (e.g., deforestation, excessive grazing and misuse, mining soil fertility by extractive farming practices leading to negative nutrient balance, etc.). Important strategies of desertification control include soil and water conservation, enhancing SOC pool, and strengthening nutrient/elemental recycling mechanisms. Important strategies include the establishment of vegetal cover on denuded soils, application of soil amendments, and conversion to restorative land use (e.g., improved pasture with controlled grazing, afforestation, conservation farming).

Lal (2001) estimates the potential C sequestration through desertification control at 0.9-1.9 Pg C/yr over a 25-50 year period (Table 2). Furthermore, improvements in soil quality through restoration of degraded soils has the important benefit of achieving food security by improving agronomic/biomass production and increasing use efficiency of input (e.g., fertilizers, irrigation, energy). Lal (2006) estimates that increasing SOC pool in degraded/desertified soils by 1 Mg C/ha/yr can increase global food production by 26-30 million Mg/yr.

Table 2. Potential of desertification control and soil restoration to sequester C (adapted from Lal, 2001).

Process	Potential of C sequestration (Pg C/yr)
Emission reduction through erosion control	0.25
Restoration of eroded soils	0.25
Restoration of physically and chemically degraded soils	<0.01
Reclamation of salt-affected soils	0.3
Agricultural intensification on undegraded soils	0.015
Fossil fuel C offset through biofuel production	0.4
Sequestration of secondary carbonates	0.2
TOTAL	1.4 (0.9-1.9)

Soil C sequestration is a common thread that links several UN Conventions (Figure 5). Indeed, SOC sequestration is truly a win-win-win strategy. An important strategy of desertification control is the establishment of biofuel/bioenergy plantations on degraded soils. Global energy uses, in the equivalent of millions of tonnes of oil, were 250 in 1800, 800 in 1900, and 10,000 in 1990. It is increasing rapidly, especially in the developing economies of China, India, Brazil, Mexico, South Africa, etc. Furthermore, there is a scarcity of high-quality soil for all competing uses. Blum (2002) reports that global land resources include 2.4% of class I land supporting 6.1% of the world population, 9.5% of class II and III land supporting 19% of the population, 33.3% of class IV, V and VI land supporting 53.6% of the population, 9% of class VII land supporting 11.5% of the population, and 45.3% of class VIII and IX land supporting 13.1% of population. Indeed, only 12% of the land surface is suitable for food and fibre production, 24% for grazing, and 31% for forest plantations. As much as 33% of the land is unsuitable for any kind of sustainable land use (Blum and Eswaran, 2004). Furthermore land area available for agricultural uses is progressively decreasing because of conversion to urban and industrial uses. The unsustainable land use has exacerbated the problem of soil degradation because of the depletion of soil organic carbon and nutrient pools, soil erosion and desertification.

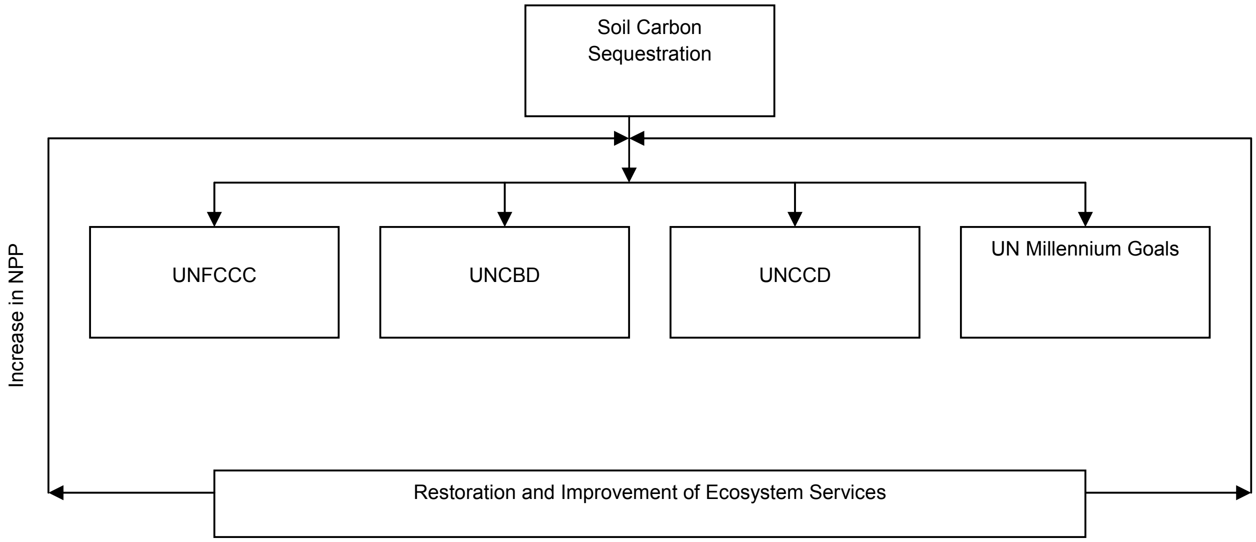

Figure 5. Link between soil organic carbon sequestration, UN Conventions and UN Millennium Development Goals.

The establishment of bioenergy plantations on some degraded/desertified soils may be a viable option. Choice of appropriate species or short rotation woody perennials or highly productive grasses can meet the needs to produce renewable sources of energy while restoring degraded soils and ecosystems. However, the use of soil amendments and installation of techniques for soil and water conservation are essential to sustainable production of biomass through energy plantations established on degraded soils.

7. Trading Carbon Credits and Promoting Soil Restoration and Desertification Control

Carbon sequestered in soils and biota can be traded as a farm commodity, and thus used to generate another income stream for resource-poor farmers. The price of C at the Chicago Climate Exchange is rather low, at about \$2/Mg of CO_2 (\$7.33/Mg of C) in December 2007. However, the price is likely to increase if the Kyoto Treaty endorsed by the Bali convention is endorsed by the world community. For example, the price of C is much higher in the European Exchange than it is in the Chicago Climate Exchange because European Union (EU) countries have accepted a mandatory cap on emissions. In addition to providing extra income, even at a low rate of US\$ 2-5/ha/yr including sequestration in soil and biomass, the concept is ecologically and politically sound. The farmers and land managers are being compensated for the ecological services provided to the world community. It would be even more appropriate if the payments for C sequestration are linked to the adoption of a restorative land use and modern innovations in soil and crop management. Any investment in soil restoration which enhances C sequestration and improves soil quality would also reverse the degradation trends, control desertification and increase biomass production while improving the environment.

The CO_2 arithmetic that would facilitate cap and trade has been presented by Broecker (2007). Rather than incremental reductions, Broecker (2007) proposes the concept of a “carbon-pie”. It is estimated that for each 4 Pg of C burnt, the atmospheric concentration of CO_2 rises by 1 ppm. For 9.1 Pg of total emissions (Table 1), we are increasing the annual concentration by about 2.3 ppm (9.1 ÷ 4 = 2.3). This 4:1 ratio, however, may change over time. Thus, if the IPCC fixes the desirable limit of CO_2 concentration at 540 ppm (Bohannon, 2007), then the size of the carbon-pie is at 640 Pg [(540 ppm – 380 ppm) x 4 Pg/ppm = 160 x 4 = 640 Pg]. The size of the carbon-pie would decrease with a decrease in the upper limit of the CO_2 concentrations in the atmosphere. Once the size of the carbon-pie is determined, each nation is allocated its share based on population and other factors. Those nations which consume more than their share of the pie would have to purchase a share from other nations which save their portion of the pie by conserving or finding alternate sources of energy.

There is another set of calculations needed to calculate the cost of using the carbon-pie in addition to national allocation. The total CO_2-eq emitted by a nation is computed as the sum of all gases [(CO_2x1) + (CH_4 x 21) + (N_2O x 310) = CO_2-eq] (Walsh, 2007). Total CO_2-eq is then multiplied by the estimated price of C offset (e.g., \$50/Mg for the European Exchange). If a nation wishes to purchase C credits from Niger, Ghana, Nepal etc., for example, it would have to pay that country accordingly.

In addition to the computations shown above, the commodification of soil C is based on developing a methodology for credible measurement of C pool in soil/biomass and its change over a known period of time. Rather than the traditional measurement of C concentration (%) in the plough layer, measurements for trading of C credits require assessment of C pool (Mg/ha) in the soil solum (1 m or more) and change in the pool (kg/ha/yr) over a short period of 1-2 years. Furthermore, these measurements need to be made over a landscape, watershed or regional scale. A protocol needs to be developed to facilitate trading of C sequestered in restored soils and ecosystems.

Conclusions

The decline in natural land-based sink capacity between 2000-2006 may be attributed to degradation and desertification of soil and biota. The serious problem of desertification, a consequence of the "tragedy of the global commons", is driven by socio-economic and political factors. The problem is exacerbated by harsh climates (e.g., Iceland) and fragile soils (e.g., sub-Saharan Africa). Principal factors include land misuse and soil mismanagement, such as extractive farming practices based on mining soil fertility and depleting soil organic matter reserves. The scarcity of prime soil resources, competing uses of soil for urban and industrial purposes, and rapidly increasing population in developing countries necessitate restoration of degraded soils and ecosystems. Carbon sequestration in terrestrial ecosystems (e.g., soils and biota) is an important strategy of restoring degraded and desertified soils. Compared to geologic and oceanic strategies, terrestrial sequestration is cost-effective and a natural process with numerous ancillary benefits. Establishing bioenergy plantations and involving the choice of appropriate species and use of suitable bio-solids and amendments are important to restoring desertified soils while producing renewable energy. The constraint of adopting recommended technologies because of the lack of resources available to small land holders can be alleviated through the trading of C credits and commodification of C sequestered in soils and biota. Soil C sequestration generates another income stream for farmers through trading of C credits. The concept of carbon-pie and payments according to the cost of offset of the desired CO_2-eq can facilitate commodification of terrestrial C.

References

Albrecht, W., 1938. "Loss of Soil Organic Matter and its Restoration" in *Soils and Men*. Yearbook of Agriculture, USDA, Washington, D.C., pp. 347-360.

Allison, F.E., 1973. *Organic Matter and Its Role in Crop Production*. Elsevier, New York, pp. 637.

Blanco-Canqui, H. and R. Lal, 2007. "Soil and Crop Response to Harvesting Corn Residues for Biofuel Production" in *Geoderma*, 141, pp. 355-362.

Blum, W.E.H., 2002. "The Role of Soils in Sustaining Society and the Environment: Realities and Challenges for the 21st Century" in *Proceedings of the 17th World Congress on Soil Sciences, 14-21 August 2002, Bangkok, Thailand*, pp. 66-86.

Blum, W.E.H. and E. Eswaran, 2004. "Soils for Sustaining Global Production" in *Journal of Food Science*, 69, pp. 37-42.

Bohannon, J., 2007. "IPCC Report Lays Out Options for Taming Greenhouse Gases" in *Science*, 316, pp. 812-814.

Broecker, W.S., 2007. "CO_2 Arithmetic" in *Science*, 315, pp.1371.

Callender,G.S.,1938. "The Artificial Production of Carbon Dioxide and its Influence on Climate" in *The Quarterly Journal of the Royal Meteorology Society*, 64, pp. 223-240.

Canadell, J.G., C Le Quére, M.R. Raupach, C.B. Field, E.T. Buitenhui, P. Ciais, T.J. Conway, N.P. Gillett, R.A. Houghton and G. Marland, 2007. *Contributions to Accelerating CO_2 Growth from Economic Activity, Carbon Intensity and Efficiency of Natural Sinks*. Available at: http://www.pnas.org/cgi/doi/10.1073/pnas.0702737104.

Doolittle, W.E., 1997. "Desertification: A World Problem" in M.J. Pasqualeti (ed.), *The Evolving Landscape*. The John Hopkins University Press, Baltimore, MD, USA, pp. 227-252.

Doornbosch, R. and R. Steenblik, 2007. *Biofuels: Is the Cure Worse than the Disease?* OECD, SG/SD/RY(2007)3.

Fagan, B., 2004. *The Long Summer: How Climate Changed Civilization*. Basic Books, New York, pp. 377.

Feller, C., 1997. "The Concept of Soil Humus in the Past Three Centuries" in D.H. Yaalon, S. Berkowiez (eds.) *History of Soil Science*. Advanced Geoecology 29, Catena Verlag, Reiskirchem, pp.15-46.

Hardin, G., 1968. "The Tragedy of the Commons" in *Science*, 162, pp. 1243-1248.

Henao, J. and C. Baanante, 2006. *Agricultural Production and Soil Nutrient Mining in Africa: Implications for Resource Conservation and Policy Development*. IFDC, Muscle Shoals, LA, pp. 10.

Himes, F.L., 1998. "Nitrogen, Sulphur and Phosphorous and the Sequestering of Carbon" in R. Lal, J.M. Kimble, R.F.Follett and B.A. Stewart (eds.), *Soil Processes and the Carbon Cycle*. CRC Publishers, Boca Raton, USA, pp. 315-320.

Howard, A., 1940. *An Agricultural Testament*. Oxford University Press, Oxford, U.K.

Howard, A., 1952. *The Soil and Health: A Study of Organic Agriculture, 2nd Edition*. The Devin-Adam Co., New York.

IFDC, 2006. "African Soil Exhaustion" in *Science*, 312, pp. 31.

IPCC, 2000. *Land Use, Land Use Change and Forestry*. Intergovernmental Panel on Climate Change. Cambridge Univ. Press, U.K.

IPCC, 2001. *The Climate Change 2001: The Scientific Basis. Working Group I.* Intergovernmental Panel on Climate Change. Cambridge Univ. Press, U.K., pp. 881.

IPCC, 2007. *The Climate Change 2007: The Scientific Basis. Working Group I.* Intergovernmental Panel on Climate Change. Cambridge Univ. Press, U.K.

Jenny, H., 1941. *Factors of Soil Formation: A System of Quantitative Pedology*. Dover Publications, New York.

Kennedy, D., 2007. "The Biofuel Conundrum" in *Science*, 316, pp. 315.

King, F.H., 1911. *Farmers of Forty Centuries*. Democrat, Madison, WI, pp. 438.

King, F.H., 1926. *Farmers of Forty Centuries, or Permanent Agriculture China, Korea and Japan*. Oxford University Press, U.K.

Kruger, J., 2006. "Global Warming Heats Up" in *Time*, 26 March, 2006.

Lal, R., 1999. "Soil Management and Restoration for Carbon Sequestration to Mitigate the Greenhouse Effect" in *Prog. Environmental Science*, 1, pp. 307-326.

Lal, R., 2001. "Potential of Desertification Control to Sequester Carbon and Mitigate the Greenhouse Effect" in *Climatic Change*, 51, pp. 35-72.

Lal, R., 2003. "Soil Erosion and the Global Carbon Budget" in *Environmental International,* 29, pp. 437-450.

Lal, R., 2004. "Soil Carbon Sequestration Impact on Global Climate Change and Food Security" in *Science*, 304, pp. 1623-1627.

Lal, R., 2006. "Enhancing Crop Yields in Developing Countries through Restoration of Soil Organic Carbon Pool in Agricultural Lands" in *Land Degradation & Development*, 17, pp. 197-209.

Lal, R., 2007. "There is No Such Thing as a Free Biofuel from Crop Residues" in *CSA News*, 52(5):12-13.

Lal, R., 2008. "Carbon Sequestration" in *Philosophical Transaction Royal Society (B)*, 363(1492): 815-830.

Lal, R. and D. Pimentel, 2007. "Biofuels from Crop Residues" in *Soil and Tillage Research*, 93, pp. 237-38.

Leopold, A., 1981. *The Land Ethic. In A Sand County Almanac*. Oxford University Press, Oxford, U.K., pp. 237-265.

Linden, E., 2006. *The Winds of Change: Climate, Weather and Destruction of Civilizations*. Simon & Schuster, New York.

Lu, R., 2001. "Combating Desertification with Seabuckthorn" in D. Pasternak and A. Schlissel (eds.), *Combating Desertification with Plants*. Kluwer Academic, New York, pp. 291-300.

Mainguet, M., 1991. *Desertification: Natural Background and Human Mismanagement*. Springer Verlaag, Berlin.

Oldeman, L.R. and G.W.J. Van Lynden, 1998. "Revisiting the GLASOD Methodology" in R. Lal, W.H. Blum, C. Valentine and B.A. Stewart (eds.), *Methods for Assessment of Soil Degradation*. CRC Press, Boca Ration, USA, pp. 423-440.

Pimentel, D. and R. Lal, 2007. "Biofuels and the Environment" in *Science*, 314, pp. 897.

Ruddiman, W.F., 2003. *Plows, Plaques and Petroleum: How Humans Took Control of Climate*. Princeton Univ. Press, Princeton.

Ruddiman, W.F., 2005. "The Anthropogenic Greenhouse Era began Thousands of Years Ago" in *Climatic Change*, 61, pp. 262-292

Semple, E.C., 1928. "Ancient Mediterranean Agriculture" in *Agricultural History*, 2, pp. 61-81.

Socolow, R.H., 2005. "Can we Bury Global Warming?" in *Scientific America*, 293, pp. 49-55.

Sommerville, C., 2006. "The Billion tonne Biofuels Vision" in *Science*, 312, pp. 1277.

Stevenson, A., 1965. *Science and Society.* W.A. Benjamin, New York.

Thaër, A., 1809. *Grundsätz der Rationnellen Landwirtschaft (1809-1812)*. Realschulbuch Ed., Berlin, Germany.

Thaër, A., 1811. *Principles of Practical Agriculture*. Translated from German by W. Shaw and C.W. Johnson. C.M. Caxton and Co. Agric. Book Publ., Berlin, Germany.

Time, 1939. “Warmer World”. 2 January, 1939.

Tyndall, J., 1863. On Radiation Throughout the Earth’s Atmosphere” in *Philosopher's Magazine* 4(25): 204-205.

UNEP, 1991. *Status of Desertification and Implementation of the United Nations Plan of Action to Combat Desertification*. UNEP, Nairobi, Kenya.

UNEP, 1992. *World Atlas of Desertification*. Edward Arnold, Seven Oaks, Nairobi, Kenya.

Wallace, A.R., 1903. *Man’s Place in the Universe*. McClure, Phillips and Co., New York,

Walsh, B., 2007. “The Cost of Being Clean” in *Time*, 29 October 2007, 54.

Weart, S.R., 2003. *The Discovery of Global Warming*. Harvard University Press, Cambridge, MA, pp. 213.

Wilhelm, W.W., J.M.F. Johnson, J.L. Hatfield, W.B. Voorhees and D.R. Linden, 2004. “Crop and Soil Productivity Response to Crop Residue Removal: A Literature Review” in *Agronomy Journal*, 96, pp. 1-17.

WMO, 2006. *Greenhouse Gas Bulletin: The State of Greenhouse Gases in the Atmosphere Using Global Observations up to December 2004*. World Meteorological Organization, Geneva, Switzerland, pp. 4.

Carbon Finance and the Millennium Development Goals: Potentials, Opportunities and Barriers

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Introduction

According to the Millennium Ecosystem Assessment (MA) (2005), large areas of land in the developing world have experienced significant degradation, driven principally by the conversion of land to socially sub-optimal cultivation practices that do not internalize medium- and long-term social costs. While global statistics should be considered uncertain, it is estimated that approximately 10% of the world's land surface is severely degraded (Hassan et al., 2000; FAO, 2007; Reynolds et al., 2007).

The advent of the market in carbon has raised the possibility of harnessing carbon finance as a mechanism for rehabilitating degraded lands through the capture ('sequestration') of atmospheric carbon in biomass and soils. Nabuurs et al. (2007) summarize several studies indicating that afforestation, reduced deforestation and forest management can potentially offset 1.3-13.8 Gt of carbon dioxide equivalent (CO_2e)/year through 2030, a figure compatible with that provided by Kauppi et al. (2001). Presenting these figures in a slightly different manner, Sedjo and Marland (2003) conclude that biological sinks have the potential to capture 10-20% of anticipated net fossil fuel emissions between now and 2050. Although these figures are much lower than offsets from industrial sources, their Millennium Development Goals (MDGs) benefits earn them further consideration.

Carbon sequestration has significant intrinsic benefits. First, it is the only climate change mitigation activity that addresses the problem of greenhouse gases (GHGs) already in the atmosphere. While it is undeniable that the bulk of global efforts should consist of emissions reductions, it makes little sense not to take steps to remove GHGs already emitted. The observed rise in global mean temperature since 1900 has thus far been approximately 0.8ºC (IPCC, 2007). However, when the full temperature impact of today's greenhouse gas concentration of 430ppm CO_2e is realized, temperature may increase by at least another 0.5ºC (Meehl et al., 2005), and possibly by as much as 1ºC (Wigley, 2005). Unlike other mitigation activities, carbon sequestration can actively serve to reduce this residual 'commitment to climate change' (Wetherald et al., 2001).

Second, carbon sequestration has the potential to open the carbon market to poor, rural communities in which industrial mitigation projects cannot be established. These communities already suffer exclusion from the global economy; to preclude their participation in the carbon economy from the outset would serve only to further isolate and impoverish them.

Finally, carbon sequestration represents the interface between climate change adaptation and climate change mitigation. That is, it simultaneously couples minimization of the negative economic, social and environmental consequences of global warming (through increasing the sustainability of rural livelihoods and enhancing ecosystem resilience) with limitation of the climate change itself (through reducing atmospheric greenhouse gas concentrations).

However, though these claims have been repeatedly made, questions have been raised as to whether such projects can, in fact, increase the productivity, resilience and sustainability of farming and natural systems, thereby increasing rural incomes and preventing rural exodus. In other words, can carbon sequestration projects sustainably finance the simultaneous benefits of climate mitigation, climate adaptation and sustainable development?

The economic viability of land rehabilitation is often marginal, especially in developing countries where the marginal cost of investment in rehabilitation is far higher than abandoning the degraded land and exploiting new lands (Glenn et al., 1993). Official Development Assistance (ODA), environmental finance such as the Global Environment Facility (GEF) and government investments are often insufficient to cover the capital-intensive costs of land rehabilitation. Approximately US$ 2 billion in ODA is available to combat desertification (Global Mechanism, 2007). Even using a conservative figure of US$ 100/ha for the costs of land rehabilitation, applied over the 300 million ha of severely degraded land identified by Oldeman (1994), this results in a global rehabilitation cost of approximately US$ 30 billion, 15 times the level of available aid, without even including newly degraded lands.

This leaves us with one key question: can the carbon market add the necessary financing to make land rehabilitation an economically viable activity? Is carbon the 'holy grail' of land rehabilitation?

1. Restoring Land Capability

Many different strategies have been shown, under controlled conditions, to successfully rehabilitate degraded land, restore land capabilities and enhance the productivity of land. However, not all have been tested in real-world situations and not all are economically feasible.

Globally, there are 3 million km^2 of lands whose degradation is classified as 'severe and extreme' (Oldeman, 1994)[2], amounting to approximately 2% of the world's land surface. The estimated cost of their rehabilitation is extremely high,

[1]Currently with the United Nations Environment Programme.

ranging from US$ 100 (degraded farmland) to US$ 40,000 (large-scale mining) per ha, depending on the severity of chemical and bio-physical losses in the soils (DOC, 2007; Datta et al., 2000; Le Houerou, 1996; Reij et al., 2005). These high costs present a formidable challenge to financing such rehabilitation through the carbon markets.

Consider a typical forestry approach to rehabilitation, using trees to stabilize and replenish the soil and the revenue from sustainable logging to cover the project's costs. Studies show that the supplemental value of a carbon layer to such a logging enterprise is very low. A temperate sustainable logging enterprise is estimated to provide US$ 300-2,660/ha/year in economic returns from timber harvests, compared with US$ 13-35/ha/year from carbon storage and sequestration, depending on carbon price (Vogt et al., 2005). Furthermore, there is an inescapable trade-off between timber revenue and carbon sequestration: maximizing the former will create losses for the latter (Kramar et al., 2005). The Afforestation/Reforestation (AR) projects approved by the Clean Development Mechanism (CDM) to date suggest that carbon revenue can increase the internal rate of return of the underlying project over a large range: between 0.5 and 7 percentage points, with the higher uplifts correlated with large-scale operations (Neeff and Henders, 2007; Yemshanov et al., 2007). In some cases, such as in Panama, potential small scale CDM Afforestation-Reforestation (AR) projects are not an attractive financial alternative for communities (when compared to current land uses of cattle raising and cropping), unless other sources of income are added (Coomes et al., 2007).

The economic value-added of improving dryland agricultural systems in developing countries is generally low. For example, in Sudan, millet, sorghum, sesame and groundnuts cost more to produce than the income from selling the product, while only 'high-end' products such as watermelon and karkadé generate a positive income. The value-added of carbon sequestration from improved agriculture in such settings (for example, through improved manure application, rotation of crops and fallow, and agro-forestry) is reported to increase the income of the farmer by only 1-4%, and little more in developed country settings (FAO, 2004; Morand and Thomassin, 2005). At current prices for carbon, this increment is too low to provide an incentive for farmers to engage in carbon projects.

But there is some evidence that shifting land use in order to restore its original (functional) capability may be a potentially viable strategy, from both environmental and socio-economic perspectives. In such projects, rehabilitation of lands that have been degraded as a result of conversion to socially sub-optimal uses (e.g. rangelands being converted to cropping, or forests being converted to grazing) show sufficient incremental carbon sequestration to warrant further investigation.

In this paper, three of the most promising land capability restoration project types are discussed. Estimated rates of carbon sequestration can be used as a proxy measure to evaluate their financial potential. However, we stress that since the financial viability of these strategies is not as yet certain, no firm conclusions can be drawn.

The three strategies are: the conversion of degraded cultivated lands into grassland or rangeland; the conversion of degraded croplands and pastures to forest; and the conversion of degraded farmland into agro-forestry systems. All three strategies aim to restore utilized (but nonetheless degraded) lands to their original ecological capability through land-use changes that also generate benefits for sustainable livelihoods and poverty alleviation.

1.1. Conversion of degraded cultivated land into grassland or rangeland

The Millennium Ecosystem Assessment concludes that between 1900 and 1950 approximately 15% of rangelands were converted to cultivated systems, and that a somewhat faster conversion has taken place in the last five decades during the so-called 'Green Revolution'. Transformation of rangelands and sylvo-pastoral dryland systems to croplands is known to increase the risk of desertification (Millennium Ecosystem Assessment, 2005).

This land capability restoration strategy foresees the restoration of former rangelands and grasslands by means of carbon-financed land-use change, soil and water conservation for rapid re-vegetation, sylvo-pastoral techniques for land capability restoration, and sustainable animal husbandry systems.

Studies indicate (Conant et al., 2001) that the conversion of degraded cultivated land to grassland pasture can result in net annual increases of soil carbon of 3% and more. In West Africa, this represents an annual sequestration rate of 0.3-0.8 tC/ha/year (Batjes, 2001). Other studies show that conversion of cropland to grassland can potentially sequester 1.2-1.7 tC/ha/year from soils alone (FAO, 2004; Freibauer, 2003; Vagen et al., 2005). Soils typically account for 70-90% of the total carbon sequestered in a grassland ecosystem.

A major concern for this type of land capability restoration approach is that of 'leakage' – the displacement of pre-project land-use activities. If farmers who are displaced by a land rehabilitation project simply move elsewhere to continue to practice subsistence agriculture, the result is further land degradation and no net carbon sequestration benefits. Such leakage can be avoided by choosing sites where farmers already have incentives to convert from low-productivity cropping to high-productivity grazing, but lack the economic resources to do so. Carbon finance could be harnessed to actively assist them in making this land-use change, with a lower attendant risk of displacement.

Another concern often raised in the context of carbon sequestration projects is the risk that such projects will create untouchable 'carbon reserves', productive land that is no longer available to local communities. In fact, in the case of grazing land this concern is largely misplaced, as there is strong evidence to indicate that well-managed grazing actually results in

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[2]As noted in MA (2005) and elsewhere, the figures of Oldeman (1994) must be used warily. However, his breakdown of degradation into different classes remains unique and therefore represents a valuable source.

higher levels of carbon sequestration. Conant et al. (2001) found that grazing management typically leads to a 3% annual increase in soil carbon. Extensive pastoral management can, therefore, be actively integrated as a positive addition to a sequestration programme, thus ensuring sustainable development benefits.

1.2. Conversion of degraded croplands and pastures to forest

This land capability restoration strategy foresees the use of afforestation and reforestation techniques, many of which are CDM-eligible, for conversion of degraded croplands and pastures. It includes compatible income-generating activities, such as fruit and medicinal production, selective logging, selective animal production, biofuel production and cropping. The potential for such cropland restoration is significant: 220 million hectares of forest land were converted to food production between 1975 and 1990, typically with adverse environmental consequences (FAO, 2000).

One CDM-AR project underway in Albania will sequester 0.9 tC/ha/year (above- and below-ground carbon) over approximately 6,000 ha, by planting trees in degraded pastures (CDM-AR-PDD Albania, 2005). Since the project lands are communal and owned by the state (to which local communities have only usufruct rights), it is unlikely that the communities will have ownership rights over the carbon credits generated. However, as the project is linked to a larger World Bank-sponsored Natural Resources Development Project (NRDP), it is expected that there will be further benefits to the local population, including employment, enhanced fodder productivity on arable land, the introduction of improved breeds of livestock, and improved alternative pastures.

A study of a conversion of unimproved pasture to forested stands of mixed native and non-native species in Puerto Rico found that, in addition to significant carbon sequestration in above-ground biomass, the soil continued to act as a carbon sink and accumulated significant additional carbon (Silver et al., 2004). Afforestation produced a net gain of 33 tC/ha in soil carbon over a 55-year period, in addition to 80 tC/ha in above-ground biomass.

Under the right conditions, afforestation of pasture lands can entail a soil carbon sequestration rate of 0.6 tC/ha/year, in addition to sequestration in above-ground biomass of approximately 1.5 tC/ha/year. In total, therefore, this type of land rehabilitation activity can yield approximately 2.1 tC/ha/year (even disregarding the carbon embodied in underground root systems), a rate that can be expected to persist for at least 50 years.

There is considerable debate as to whether, and how, the current CDM rules and procedures concerning AR should be revised and improved. One of the concerns is that under the current Small-Scale Simplified Modalities and Procedures, and faced with the prevailing market price for credits, the costs of implementing small-scale carbon projects represent a significant fraction of the revenues subsequently generated: very little annual income would actually reach the low-income land owner (Schlamadinger et al., 2006).

Another concern is that the sustainable development benefits of these AR projects are likely not very high. Given the (appropriately) strict requirements of the approved CDM project methodologies to limit 'leakage', there are significant disincentives for project developers to execute projects in areas with large/poor rural populations. It is likely, therefore, that the carbon market will favour 'quick fix' monoculture projects that reliably sequester carbon but which generate few sustainable development benefits – and which may, in some cases, cause active harm to local livelihoods, biodiversity and watersheds.

1.3. Conversion of degraded farmland into agro-forestry systems

This strategy foresees the conversion of unsustainable farming into sustainable agro-forestry systems, through inter-cropping, zero-tillage and other techniques for sustainable crop production; the introduction of live fencing, hedgerows and fruit trees; and selective harvesting of biomass (e.g. for animal production or biofuel). Agro-forestry encompasses a broad range of practices that incorporate trees into farming systems, such as shade-grown coffee plantations and 'alley cropping' systems using leguminous trees to fertilize annual crops such as maize.

Writing in 2001, Kauppi et al. concluded that, globally, agro-forestry systems had the potential to sequester and store 26 million tC/year by 2010. A further 391 million tC/year could be sequestered by 2010 if an estimated 630 million hectares of unproductive cropland and grassland were converted to agro-forestry. The six year delay since 2001 without a global agro-forestry programme must make us push these returns back until at least 2017, but the general conclusion that agro-forestry can make a significant double contribution to poverty alleviation and climate change mitigation still stands.

Montagnini and Nair (2004) estimate storage of carbon by the tree component in agro-forestry systems at 9 tC/ha in a semi-arid environment, 21 tC/ha in a sub-humid environment, 50 tC/ha in a humid environment and 63 tC/ha in temperate regions. Reporting for the IPCC, Sampson and Scholes (2000) estimate a 'central' carbon sequestration rate for agro-forestry of 3.1 tC/ha/year.

Studies in India on planting tamarind on degraded cropland have yielded a net above-ground carbon sequestration rate of 0.2 tC/ha/year, in addition to the income from the sale of fruit and green leaves. In Mexico, planting 133 trees (*Cedrela odorata*) as windbreaks around 1 ha farms has resulted in an average 0.4 tC/ha/year being sequestered above-ground (PlanVivo, 2008).

While these estimates provide some boundaries for assessing the financial viability of agro-forestry to sequester carbon, much will depend on the particular project application and context. But the intrinsic characteristics of agro-forestry make it an attractive strategy to deploy for restoring land capability in situations where cropland degradation has set in. In addition to the carbon benefits, it can enhance and diversify food and income streams in the form of fruit, vegetable, oil, spices, medicine, timber and craft wood, and enhance the productivity of annual crops such as maize, cassava and rice through restoring ecological functions and services.

2. The Potential for Harnessing Carbon Finance

The commodification of carbon through trading of carbon credits under the Kyoto Protocol and alternative ('voluntary') market mechanisms represents a potential source of revenue for restoring land capability. By doing so, carbon markets offer the potential to deliver the triple benefits of climate change mitigation, enhanced resilience to adapt to climate change, and sustainable livelihoods.

However, the number of bio-carbon projects selling on the market at the moment is far lower than the potential suggests. Current market conditions, as well as a less-than-enabling environment, are proving to be disincentives to developing carbon sequestration projects that work with small land-users. There are several key barriers, outlined in more detail below, that increase the transaction costs of small-scale projects, to such an extent that transaction costs account for a significant fraction of potential revenue. As much of the transaction cost burden is attributable to fixed costs, there is a clear economic incentive to 'dilute' such costs through project expansion: project investors will tend to favour large-scale, privately-owned sequestration projects over small-scale producer/local land user-owned projects. The sustainable development benefits of such large-scale projects may not be very high, and, in some cases, may result in exploitation and expropriation of the rights of poor farmers and herders.

Under current conditions, carbon revenue alone is unlikely to significantly enhance the financial returns from small-scale, high sustainable development projects. But when combined and sequenced with other potential revenue streams, the 'carbon layer' might be sufficient to transform an unattractive project into a financially viable one, offering a suite of associated sustainable development benefits. Such additional revenue streams can arise from the underlying project (crop yields, animal production, timber and non-timber sales); from the addition of other income sources (such as Payment for Environmental Services (PES)); or from the addition of multiple carbon layers to the same project (e.g. combining carbon credits from bio-sequestration with carbon credits from biofuels such as *Jatropha spp.*).

3. Barriers in Efficient Carbon Financing

There are a number of barriers within the current CDM rules to efficient harnessing of carbon finance for restoration of land capability. The following outlines a few of these barriers.

3.1. Up-front costs and risks

All bio-sequestration projects are faced with high up-front investment costs (land, seeds, labour, etc.), delayed return on investment, low rates of return (compared with industrial sectors) and high perceived risks. Land-use projects with environmental and social components are often not sufficiently profitable to attract the financing required to kick-start the project cycle. Once implemented, these projects may provide carbon credits at very competitive rates, but they have difficulty attracting pre-operational private sector capital in order to advance through the various project cycle steps (Neeff and Henders, 2007). Unless smallholders are capable of accepting early losses or low profits, or unless there is low-cost credit available, smallholders are unlikely to adopt a new system incorporating a carbon element (Wise and Chaco, 2005).

Another factor of fundamental importance is the widespread lack of clarity, or lack of equity, in land and carbon ownership. Private ownership strategies for AR projects, while simpler and less risky than common ownership strategies, do not typically generate as many development benefits. On the other hand, common ownership may lead to unwieldy project management, may introduce a free-rider dynamic amongst participants, and may experience greater difficulties securing commercial credit to cover up-front costs.

3.2. Transaction costs

Attention should be paid to reducing the transaction costs associated with CDM Land Use, Land Use Change and Forestry (LULUCF) projects. Current approved technologies and methods for measuring carbon sequestration with the prescribed degree of accuracy are cumbersome, costly and time-consuming. Furthermore, there is generally insufficient capacity in developing countries to validate and verify LULUCF projects: consultants often have to be flown in from Europe or North America to conduct on-site inspections.

It is estimated that the costs for CDM AR project preparation lie between US$ 11,000-180,000, with additional costs associated with validation (US$ 6,000-80,000) and verification (US$ 15,000-25,000 per audit, performed every 5 years) (Krey, 2005; Neeff and Henders, 2007). These figures do not include search costs (finding a buyer), negotiation costs, or the cost of actually monitoring the carbon sequestered. Including undergrowth and soil in the monitoring system is often not economically viable, even where monitoring capacities are high, due to the spatially variable nature of these carbon pools, their relative inaccessibility and their dispersed-storage characteristics (Robertson et al., 2004). Economic modeling suggests that including soil carbon in the monitoring system is worthwhile only if verification costs are less than US$ 8.90 per hectare (Wise and Chaco, 2005).

Many transaction costs are fixed, producing significant production economies of scale and leading many to conclude that projects generating less than 50,000 tCO_2e annually will be unable to compete in the global market (e.g. Capoor and Ambrosi, 2006; Krey, 2005). A valuable policy response to such observations would be to promote project bundling (aggregating) institutions, such as single-desk sellers or producer co-operatives. Pooling mechanisms are typically used to manage risk, and there is a long history of product pooling among small-scale resource producers such as Indian rubber tappers (Zant, 2001), Ivoirian cocoa farmers (Lloyd et al., 1999) and western Canadian wheat farmers (Biggs et al., 2006). Increased scale of production and risk distribution are achieved through such aggregation and the ability of such institutions to participate in international markets and adjust pricing behaviour in the face of uncertainty has been well documented (Tucker, 2001, Zant, 2001). Bundling is desirable because it allows many relatively fixed costs (especially those associated with project design, verification, negotiation and finding a buyer) to be spread over a larger number of carbon offsets than could be generated by a single farmer.

3.3. CDM requirements

The issue of non-permanence (i.e. the potential for carbon sinks to release some or all of their carbon) is a critically important one for projects that sequester carbon for land rehabilitation. Both the type of 'reversibility event' and its consequences vary considerably. Some events (e.g. drought) may kill trees but leave them standing with most of their carbon intact over the short- and medium-term. Trees uprooted by storms, however, decompose quickly and are often utilized for fuel wood. Some events, such as earthquakes and drought, are difficult to predict, while others, such as seasonal flooding or fires, can be forecast fairly easily.

For predictable events, risk can usually be reduced during the project design stage: site selection, management practices and species planted will all mitigate certain risks. Risks that cannot be addressed in these ways can be addressed through financial mechanisms such as insurance, weather derivatives or institutionally-determined caps on how many credits can be sold. The most common method (and the one enshrined in CDM regulations) is to require a conservative estimation of a project's carbon potential at all phases of project planning, monitoring and validation. Conservatively estimating a project's carbon potential at the outset can implicitly incorporate the effect of reversibility events.

At an institutional level, the CDM addresses the permanence problem through the issuance of 'expiring Certified Emission Reductions (CERs)', which expire after varying durations according to differing accounting procedures: short-term (temporary CERs (tCERs)) or long (long-term CERs (lCERs)). It must be recognized, however, that community-based, development-oriented projects tend to reduce the permanence risk relative to large-scale, corporate-driven projects by making permanence an element of long-term livelihood strategies rather than a short-term financial investment. While even the most carefully managed project is vulnerable to stochastic events, incorporating permanent forest cover into the life of a community improves – at the very least – the chances of immediate reforestation after a local reversibility event.

Soil organic carbon is currently eligible for crediting under CDM LULUCF rules. However, it is credited in the form of expiring CERs, just as is above-ground carbon. This is despite the fact that the risk of non-permanence is much lower for soil carbon than it is for above-ground biomass: as long as the land-use and environmental conditions do not change, soil carbon can effectively be preserved as a permanent sink. The global potential to sequester soil carbon is very high, estimated to be between 0.4-1.2 Gt per year (Lal, 2004). This potential could more easily be achieved if soil carbon were to be credited using permanent CERs or, at least, an instrument with greater permanence than expiring CERs.

Furthermore, the CDM permits AR projects only on areas without forest since 31 December, 1989. This is to prevent perverse incentives being established whereby land owners could generate carbon revenue by removing virgin forest and replacing it with secondary forest plantations. However, the 1989 cut-off date penalizes landscapes where genuine efforts at reforestation have been attempted and results in ecological discontinuities that undermine contemporary rehabilitation efforts. Two AR CDM methodologies (AR-AM0002 and AR-AM0005) have been approved within the past year that acknowledge this problem. They explicitly permit areas upon which failed, failing or size-restricted forestry activities have been initiated to be included in CDM-eligible AR projects so long as any pre-project AR sequestration is incorporated into the project baseline. The majority of approved AR CDM methodologies do not include this option, however, limiting the ability of project developers to execute projects in areas where AR has failed before. This acts as an inappropriate limit on potentially poverty-alleviating development.

4. Relaxing Carbon Market Regulations

The effects of removing (or lowering) the barriers outlined above are evident from a brief examination of markets with fewer regulations than the CDM, such as the voluntary over-the-counter (OTC) offset market and the Chicago Climate Exchange (CCX).[3]

Investors participate in the voluntary markets in order to demonstrate corporate social responsibility and environmental integrity. Since these markets are not subject to international treaties and market participants do not face legal emission caps, the accounting procedures and project monitoring regimes are more relaxed than for the CDM, and the transaction costs are commensurately lower (Hamilton et al., 2007).

In this less regulated environment, 36% of credits sold (by volume) are sourced from forestry projects – as opposed to fewer than 1% of CERs in the CDM. However, three important caveats must be noted. First, 73% of total credits traded in the OTC and CCX markets are sourced from the United States and Europe from heavily forested regions where many of the 'low-hanging fruit' (such as hydrofluorocarbon (HFC) decomposition projects) that have dominated the CDM are unavailable. As

[3]The following discussion is based on the results of surveys overseen by New Carbon Finance and the Ecosystem Marketplace published by Hamilton et al. (2007).

such, it is not clear how forestry projects would compete against less expensive options. Second, three-quarters of the forestry credits in these markets were sourced from large-scale projects generating more than 100,000 tCO_2e per year – projects that may not necessarily provide significant development opportunities. Third, the voluntary markets are small relative to the regulated markets, equivalent to only 2% of the volume of the EU Emissions Trading Scheme and 5% of the volume of the CDM. This suggests that the absolute volume of forestry credits in these voluntary markets is approximately the same as that currently produced in the CDM.

Nonetheless, these results suggest that in an environment devoid of low-hanging fruit with more relaxed project regulations, AR projects can flourish relative to other project types.

5. Recommendations

To achieve the 'triple' benefits of climate change mitigation, enhanced adaptation and sustainable livelihoods, greater attention should be paid to projects that restore land capability. In particular, emphasis should be placed on projects that encourage re-conversion of degraded land to its highest ecological capability, notably cropland to rangeland in arid systems, and degraded pastureland to sustainable forest management in humid systems. Community participation and ownership of such projects is a key element to ensuring sustainable development as well as to enhancing the permanence of the carbon sequestered.

The carbon market can significantly catalyze land rehabilitation if the economic and social barriers are lifted and market incentives are created that foster greater equity. It is recommended that barriers to participation in the market by small-scale landholders be lifted. Furthermore, modification of certain CDM rules would make a large difference to the financial viability of land restoration projects. Of particular note are the following:

a) Market transformation through relaxation of the eligibility requirements under CDM LULUCF.
   (i) Allow the inclusion of more land-use types, ecosystems and project-types into the LULUCF category.
   - Expand definitions from forests to also include also grasslands and other biomes.
   - Avoid emissions through fire management in grassland and forests.
   - Devise rules to allow reforestation and revegetation on land deforested after 1989, subject to safeguards to prevent system gaming.

   (ii) Expand the role of soil carbon in the CDM.
   - Soil carbon is far more permanent than above-ground biomass. This should be recognized in project crediting, which should not be in the form of expiring CERs, but something more akin to a permanent CER. Since permanent CERs fetch a higher price in the market than expiring CERs, the financial viability of soil sequestration projects would be enhanced.
   - Alternatively, the CDM would grandfather temporary CERs and convert them to permanent CERs after an extended period of validation, if necessary at a discount (Bosquet, 2006).

   (iii) Create economies of scale in AR while promoting small-holder production.
   - Revise upward the limit on small-scale AR projects from 8,000 tCO_2e/year to 30,000 tCO_2e/year (Schlamadinger et al., 2006) or 40,000 tCO_2e/year (Bosquet, 2006).
   - Promote bundling of AR projects, allowing the 'bundle' of projects to surpass the 50,000 tCO_2e/year glass ceiling while preserving the use of the Small-Scale Simplified Modalities and Procedures.

   (iv) Closely monitor the 1% cap on carbon mitigation volumes that can be sourced from LULUCF.
   - While the current volume of AR projects is only an estimated 1/20 of this 1%, if the cap begins to become binding (and thereby limiting to the development potential of the CDM), it should be removed so as to encourage rural poverty alleviation.

b) Enhancement of the Enabling Environment
   (i) Analysis of financial viability of different land restoration strategies, combining different income sources.
   - The potential for combining and sequencing different income sources (agricultural commodities, biofuels, multiple carbon layers, etc.) to increase the profitability of land restoration projects needs to be analyzed in greater detail before it can be promoted in developing countries. ODA funding could prove instrumental in undertaking such detailed financial and social analysis of the 'carbon business model' for restoration of land capability.

   (ii) Increase the availability of credit to cover up-front costs.
   - ODA funding should be encouraged for start-up funds to help defray investment costs, and to help absorb market risks in the early stages of project preparation and implementation. Ultimately, with market transformation and enhanced enabling environments, the conditions should become conducive for commercial loans to cover such up-front costs.

   (iii) Public investment in research and development of reliable and low-cost technologies for measuring soil carbon.

   (iv) ODA funding should increase capacities of smallholders, project developers, government entities and other intermediaries to engage equitably in the carbon market.

Conclusion

There is significant potential for harnessing carbon finance for restoration of land in such a way as to ensure triple benefits from climate mitigation, climate adaptation and sustainable development. However, this potential cannot be realized under current market conditions.

CDM rules and transaction costs for AR sequestration projects have skewed the market towards projects that are large-scale and favour private developers. Such projects tend not to produce high sustainable development outcomes for the poorest of the poor, and the simultaneous ‘triple benefits’ are often not evident. Projects associated with other land-use types, such as grasslands, wetlands and cropland, that could potentially generate very high sustainable development benefits, are not eligible under current CDM rules. Furthermore, the difficulties that private-sector operatives often encounter in managing risks, in establishing tenure rights via land markets and/or engaging in negotiations with national/regional governments and local communities have resulted in a volume of AR carbon credits well below the 1% cap LULUCF credits permitted under CDM rules.

A few key changes to the CDM rules would generate greater incentives, reduce risk and create the right market conditions for smallholder and small-scale carbon sequestration projects, offering triple-benefit outcomes. These changes can be summarized as follows:

- Market transformation through relaxation of the eligibility requirements under LULUCF CDM: Allow the inclusion of more land-use types, ecosystems and project types into the LULUCF category; increase the size threshold of small-scale AR projects; expand the role and eligibility of soil carbon in the CDM.

- Enhancement of the enabling environment: Public investment in detailed financial and social analysis of the ‘carbon business model’ for restoration of land capability; public investment in the research and development of reliable, low-cost technologies for measuring bio-carbon; improved availability of credit to cover up-front project development costs; enhanced capacities of smallholders, project proponents, government entities and other intermediaries to engage equitably in the carbon market; promotion of project bundling and aggregating institutions to allow the rural poor to take advantage of economies of scale.

References

Batjes, N.H., 2001. “Options for Increasing Carbon Sequestration in West African Soils: An Exploratory Study with Special Focus on Senegal” in *Land Degradation & Development*, 12, pp.131-142.

Biggs, J., S. Laaksonen-Craig, K. Niquidet and G. Van Kooten, 2006. “Resolving Canada-US Trade Disputes in Agriculture and Forestry: Lessons from Lumber” in *Canadian Public Policy – Analyse de Politiques*, 32 (2), pp.1-13.

Bosquet, B., 2006. *Simple Proposals for a Future Regime on Forests and Agriculture*. World Bank. COP-12 Side Event, Nairobi, November 14, 2006.

Capoor, K. and P. Ambrosi, 2006. *State and Trends of the Carbon Market 2006*. Joint Publication by International Emissions Trading Association and Carbon Finance Unit of the World Bank, Washington, D.C.

Conant, R.T., K. Paustian and E.T. Elliot, 2001. “Grassland Management and Conversion into Grassland: Effects on Soil Carbon” in *Ecological Applications*, 11 (2), pp.343-355.

Coomes, O.T., F. Grimard, C. Potvin and P. Sima, 2007. “The Fate of the Tropical Forest: Carbon or Cattle?” in *Ecological Economics,* 65 (2), pp.207-212.

Datta, K., de Jong, C. and Singh, O. (2000), ‘Reclaiming salt-affected land through drainage in Haryana, India: a financial analysis’, *Agricultural Water Management*, 46, p.55-71.

US Department of Commerce, 2007. *2007 Background OF US Coal Industry*. Available at: www.ita.doc.gov/td/energy/2007%20Coal%20Assessment%20.pdf.

FAO, 2000. *Our Land, Our Future.* FAO & UNEP, Rome and Nairobi.

FAO, 2004. “Carbon Sequestration in Dryland Soils” in *World Soil Resources Report 102*, FAO, Rome.

FAO, 2007. “Land Degradation Assessment [TERRASTAT CD-ROM] in *FAO Land and Water Digital Media Series*, Number 20, FAO, Rome.

Freibauer, A., 2003. “Biogenic Emissions of Greenhouse Gases from European Agriculture” in *European Journal of Agronomy*, 19 (2), pp.135-160.

Glenn, E., V. Squires, M. Olsen and R. Frye, 1993. “Potential for Carbon Sequestration in the Drylands” in *Water, Air, and Soil Pollution*, 70, pp.341-355.

Global Mechanism, 2007. *Financial Information Engine on Land Degradation*. Available at: http://www.gmfield.info/dashboard/dashboard.asp.

Hamilton, K., R. Bayon, G. Turner and D. Higgins, 2007. *State of the Voluntary Carbon Markets: Picking Up Steam – Executive Summary*. Katoomba Group's Ecosystem Marketplace (Washington) and New Carbon Finance (London).

Hassan, R., R. Scholes and N. Ash (eds.), 2000. *Millennium Ecosystem Assessment Ecosystems and Human Well-Being: Volume 1. Current State and Trends*. Island Press, Washington, D.C.

Intergovernmental Panel on Climate Change (IPCC), 2007. *Climate Change 2007: The Physical Science Basis: Summary for Policymakers*. IPCC Secretariat, Geneva, Switzerland.

Kauppi P., R. Sedjo and J. Liski, 2001. "Technological and Economic Potential of Options to Enhance, Maintain and Manage Biological Carbon Reservoirs and Geo-engineering', in Metz, B., O. Davidson, R. Swart and J. Pan (eds.), *Climate Change 2001: Mitigation - Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)*. Cambridge University Press, Cambridge, pp.303-343.

Kramar E., G. van Kooten and I. Vertinsky, 2005. "Managing Forest and Marginal Agricultural Land for Multiple Trade-offs: Compromising on Economic, Carbon and Structural Diversity Objectives" in *Ecological Modelling*, 185 (2-4), pp.451-468.

Krey, M., 2005. "Transaction Costs of Unilateral CDM Projects in India – Results from an Empirical Survey" in *Energy Policy*, 33 (18), pp. 2385-2397.

Lal, R., 2004. "Soil Carbon Sequestration to Mitigate Climate Change" in *Geoderma*, 123, pp. 1-22.

Le Houerou, H., 1996. "The Role of Cacti (*Opuntia* spp.) in Erosion Control, Land Reclamation, Rehabilitation and Agricultural Development in the Mediterranean Basin" in *Journal of Arid Environments*, 33, pp.135-159.

Lloyd, T., C. Morgan, A. Rayner and C. Vaillant, 1999. "The Transmission of World Agricultural Prices in Côte d'Ivoire" in *The Journal of International Trade & Economic Development*, 8 (1), pp.125-141.

Meehl, G.A., W.M. Washington, W.D. Collins, J.M. Arblaster, A. Hu, L.E. Buja, W.G. Strand and H. Teng, 2005. "How Much More Global Warming and Sea Level Rise?" in *Science*, 307, pp.1769-72.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Desertification Synthesis*. World Resources Institute, Washington, D.C.

Morand, H. and P. Thomassin, 2005. "Changes in Quebec Cropping Practices in Response to a Carbon Offset Market: A Simulation" in *Canadian Journal of Agricultural Economics*, 53, pp. 403-424.

Montagnini, F. and P.K.R. Nair, 2004. "Carbon Sequestration: An Under-exploited Environmental Benefit of Agroforestry Systems" in *Agroforestry Systems*, 61, pp.281-295.

Nabuurs, G.J., O. Masera, K. Andrasko, P. Benitez-Ponce, R. Boer, M. Dutschke, E. Elsiddig, J. Ford-Robertson, P. Frumhoff, T. Karjalainen, O, Krankina, W.A. Kurz, M. Matsumoto, W. Oyhantcabal, N.H. Ravindranath, M.J. Sanz Sanchez, X. Zhang, 2007. "Forestry" in Metz, B., O.R. Davidson, P.R. Bosch, R. Dave and L.A. Meyer (eds.), *Climate Change 2007: Mitigation - Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge University Press, Cambridge, United Kingdom and New York, USA.

Neeff, T. and S. Henders, 2007. *Guidebook to Markets and Commercialisation of Forestry CDM Projects*. Technical Manual 65, CATIE.

Oldeman, L.R., 1994. "The Global Extent of Soil Degradation" in Greenland, D.J. and I. Szabolcs (eds.), *Soil Resilience and Sustainable Land Use*. CAB International, Wallingford, pp.99-118.

PlanVivo, 2008. *Technical Specifications*. Available at: http://www.planvivo.org/fx.planvivo/scheme/manual-specification.aspx.

Reynolds, J., D. Smith, E. Lambin, B. Turner, M. Mortimore, S. Batterbury, T. Downing, H. Dowlatabadi, R. Fernandez, J. Herrick, E. Huber-Sannwald, H. Jiang, R. Leemans, T. Lynam, F. Mastre, M. Ayarza and B. Walker, 2007. "Global Desertification: Building a Science for Dryland Development" in *Science*, 316, pp.847-851.

Reij, C., G. Tappan and A. Belemvire, 2005. "Changing Land Management Practices and Vegetation on the Central Plateau of Burkina Faso (1968-2002)" in *Journal of Arid Environments*, 63 (3), pp.642-659.

Robertson, K., I. Loza-Balbuena and J. Ford-Robertson, 2004. "Monitoring and Economic Factors Affecting the Economic Viability of Afforestation for Carbon Sequestration Projects" in *Environmental Science & Policy*, 7, pp.465-475.

Sampson, R.N. and R.J. Scholes, 2000. “Additional Human-induced Activities”, Article 3.4 in Watson, R.T., I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo and D.J. Dokken (eds.), *Land Use, Land-Use Change & Forestry: A Special Report of the IPCC*. Cambridge University Press, Cambridge, United Kingdom.

Schlamadinger, B., R. Lal and N. Bird, 2006. *A Proposal to Increase the Small Scale Limit of A/R projects*. ENCOFOR and Joanneum Institute.

Sedjo, R. and G. Marland, 2003. “Inter-trading Permanent Emissions Credits and Rented Temporary Carbon Emissions Offsets: Some Issues and Alternatives” in *Climate Policy*, 3 (4), pp. 435-444.

Silver, W.L., L.M. Kueppers, A.E. Lugo, R. Ostertag and V. Matzek, 2004. “Carbon Sequestration and Plant Community Dynamics Following Reforestation of Tropical Pasture” in *Ecological Applications*, 14 (4), pp.1115-1127.

Tucker, M., 2001. “Trading Carbon Tradable Offsets Under Kyoto’s Clean Development Mechanism: the Economic Advantages to Buyers and Sellers of Using Call Options” in *Ecological Economics*, 37, pp.173-182.

Vagen, T.-G., R. Lal and B.R. Singh, 2005. “Soil Carbon Sequestration in Sub-Saharan Africa: A Review” in *Land Degradation & Development*, 16, pp.53-71.

Vogt, K.A., M.G. Andreu, D.J. Vogt, R. Sigurdardottir, R.L. Edmonds, P. Schiess and K. Hodgson, 2005. “Societal Values and Economic Return added for Forest Owners by Linking Forests to Bioenergy Production” in *Journal of Forestry*, 103 (1), pp.21-27.

Wetherald, R.T., R.J. Stouffer and K.W. Dixon, 2001. “Committed Warming and its Implications for Climate Change” in *Geophysical Research Letters*, 28 (8), pp. 1535-1538.

Wigley, T.M., 2005. “The Climate Change Commitment” in *Science*, 307, pp.1766-1769.

Wise, R. and O. Cacho, 2005. “A Bio-economic Analysis of Carbon Sequestration in Farm Forestry: A Simulation Study of *Gliricidia sepium*” in *Agroforestry Systems*, 64, pp.237-250

Yemshanov, D., D. McKenney, S. Fraliegh and S. D’Eon, 2007. “An Integrated Spatial Assessment of the Investment Potential of Three Species in Southern Ontario, Canada, Inclusive of Carbon Benefits” in *Forest Policy and Economics*, 10 (1-2), pp.48-59.

Zant, W., 2001. “Hedging Price Risks of Farmers by Commodity Boards: A Simulation Applied to the Indian Natural Rubber Market” in *World Development*, 29 (4), pp.691-710.

Harnessing Carbon Finance for Land Restoration: Can it be Done and Will it Work?

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Introduction

For smallholder farmers in developing countries, the costs of combating land degradation and establishing more sustainable farming systems include: the labour spent on land contouring; the establishment of living soil protection barriers or soil improving shrubs; the lower yields (in early years) when converting from burning to non-burning cultivation systems; the foregone production from areas where the soil is simply too fragile to use for agriculture; and, the effort of organising and regulating the use of common grazing and fuel wood production areas.

1. The Inefficiency of Aid to More Sustainable Farming

It is difficult to quantify these costs (or barriers) in monetary terms, especially in subsistence economies where wage rates are seasonal and depend on social relations as much as on economic circumstances. One innovative smallholder farmer in southern Mexico who had been the first in the village to adopt non-burning maize production told me how he had been mocked by his neighbours for three years before some started to follow his lead. However, on the basis of additional labour inputs required on yields forgone in early years, I estimate the total cost per hectare typically ranges from US$ 500-2000 (Dregne and Chou, 1992; De Jong et al., 1996). After incurring these costs, it may be several years before the benefits from soil improvement can be clearly appreciated.

Unfortunately, few aid-based programmes get anywhere near overcoming these cost barriers. First, it is not common for aid programmes to deliver financial assistance for land improvement activities directly to farmers; in most cases, the only physical resources delivered to farmers are inputs such as seed, fertiliser, or equipment. While these inputs may be welcome, they do not cover the costs mentioned above.

Second, most aid is delivered without any conditions attached. As one farmer said: “this government aid is like the rain; sometimes it falls and sometimes it doesn’t; there is nothing you can do about it; just hope for the best”.

Third, aid frequently creates dependency rather than stimulating productivity, organisational capability and enterprise (Moss et al., 2006; Brautigam and Botchwey, 1999). In many developing countries, farmers and village representatives expect to be paid to turn up to meetings to discuss local development – these “sitting fees” are a strong indicator of cynicism and dependency, for surely if people believed that going to a meeting would really make a difference to their lives then they would not need to be paid to turn up.

Finally, a large proportion of the aid directed toward sustainable land use never gets to where it could make a difference – it is either absorbed by bureaucracy, diverted elsewhere, or used up by aid organisations in workshops, consultancy fees, research or internal capacity-building. When finance finally does get through to grassroots organisations, it often arrives at the wrong time or with political strings attached. I recall, several years ago, having to spend several hundred thousand dollars of donor money on tree seedlings in two weeks because the reporting timeframes set by the World Bank were based on financial schedules, not on the seasons.

2. A New Hope – Carbon Finance for Environmental Benefits

Given the deep problems with using aid to address the problem of land degradation, it is not surprising that many organisations have become interested in the prospect of undertaking sustainable land management and ecosystem restoration activities with funding from the provision of environmental services, in particular the sequestration of carbon.

When the Clean Development Mechanism was finalised in Marrakech in 2001, the prospect of carbon finance through this flexible mechanism of the Kyoto Protocol being applied to protect and restore woodlands and agricultural systems appeared to offer a major new opportunity.

Unlike aid, carbon finance would be based on a measurable indicator of physical progress (increased carbon stocks in soil and above ground biomass). Unlike aid, environmental services represent a product in the form of an environmental certificate that can be produced and sold through markets, allowing communities to break free from dependency on handouts and the unequal relationship between donor and recipient. For many organisations, carbon finance appeared to provide a means of circumventing the established donor structures, the dreaded aid bureaucracy. Above all, carbon finance appeared to hold open the prospect of far greater financial flows than had previously been contemplated for this sector.

In 2001, hopes were high within the multilateral agencies: a United Nations Environment Programme (UNEP) press release stated: “a new chance to fight poverty, environmental degradation and chronic energy shortages across Africa is fast emerging as a result of the latest negotiations to fight global warming”. Later in the same year Pedro Sanchez, Director General of the World Agroforestry Centre (ICRAF) announced: "Africa must use this [CDM] as a new development opportunity. It opens the way for work that will not only have environmental benefits but ones related to health, hunger and poverty".

[1]Currently with Ecometrica.

Around this time, the World Bank was establishing its BioCarbon Fund[2] – its aim: to kick-start the land use carbon market in developing countries with several hundred million dollars of initial investment. A new breed of carbon finance and development experts started to emerge: consultants, brokers and fund managers.

The Intergovernmental Panel on Climate Change produced over 500 pages of "Good Practice Guidelines for Land Use, Land Use Change and Forestry"; development agencies from Austria to United States Agency for International Development (USAID) funded training workshops all over the developing world on "how to access carbon finance for forestry and land use projects"; NGOs and academics debated the opportunities and threats associated with marketing the carbon attributes of forests. International verification companies hired new staff to audit forestry projects.

But while the rhetoric was spectacular and the workshops interminable, action on the ground was difficult to detect. Despite dozens of concept notes and project design documents flying between NGOs, consultants and carbon brokers, very few real projects appeared to be crystallizing. In 2007, while official enthusiasm for CDM forestry remained high within several of the multilateral agencies, it had become apparent to most organisations with practical experience in land restoration that "the Emperor had no clothes", or was at least, very scantily clad. Out of over 700 projects in the CDM, only one afforestation project in China had been approved, amounting to less than 0.1% of the total volume of reductions expected from the mechanism by 2012.

3. Breaking Down the Barriers

For those aware of the barriers to achieving sustainable land in rural communities in developing countries, it is not difficult to understand how the CDM excludes practical land use and forestry projects in developing countries by virtue of its design. Table 1 below contrasts the needs of farmers.

Table 1. Community needs for implementing sustainable land use activities versus CDM design features.

Needs	CDM design
Help with conserving and restoring a range of agro-ecosystems and woodlands.	Restricted to afforestation / reforestation of land deforested prior to 1990.
Up-front resources to cover costs over 3 to 5 years, before productivity payback is felt.	Retrospective crediting of carbon uptake over previous five years. Only very fast growing species grown on large scale likely to generate significant carbon revenue in five years.
Recognition of the multiple benefits of sustainable land use in the price of carbon from these activities (higher price).	Carbon credits discounted for risk through "temporary crediting" (lower price).
Long-term view of the carbon and sustainability benefits of sustainable land use.	Timeframe of CDM is currently limited to 2012. No certainty over market or rules beyond this date.
Simple process with minimal bureaucracy.	Highly bureaucratic and rigid process requiring approval by different national and international agencies. Deviation from project plan likely to result in loss of registration.
Ability to start small and scale up across a region, learning by doing.	Complex rules for bundling (grouping) of projects. Projects are considered to be of fixed size and duration.
Simple process for monitoring progress based on achievement of readily measured milestones.	Complex carbon quantification methodologies that are difficult to apply to developing country situations.

These fundamental differences between the needs of communities and the structure of the CDM explain why the mechanism has not worked for land restoration activities.

Efforts to overcome these structural problems by making minor adjustments to the scheme or by spending more time on training and CDM workshops have little prospect of success.

Does the failure of the CDM to provide a practical framework for promoting sustainable land use in developing countries mean that carbon finance should be written off as a promising model? I believe not.

Outside the bureaucratic confines of the CDM, there has been a small but innovative carbon market developing in the voluntary sector. The voluntary carbon sector has attracted a fair amount of criticism from the media and some environmental organisations and there have been some notable project failures and questionable marketing practices. Nevertheless, there have also been enough successes to indicate that where carbon finance is structured according to the needs of communities and small farmers, it can be highly effective at promoting the adoption of agroforestry systems, small scale forestry activities and community managed conservation areas.

The voluntary carbon sector is now starting to develop its own standards and guidelines and a number of certification schemes are under development – notably the Community, Carbon and Biodiversity Standard (CCBS)3, which was developed by The Nature Conservancy (US) in collaboration with a number of NGOs and research organisations; and the

[2]See: http://carbonfinance.org/Router.cfm?Page=BioCF.
[3]See: http://www.climate-standards.org/index.html.

Plan Vivo System[4] developed by the Edinburgh Centre for Carbon Management (UK), El Colegio de la Frontera Sur (Mexico) and various community based organisations.

Reasons for the relative success of projects started in the voluntary carbon market include:

- the provision of up-front finance for the establishment of agroforestry and ecological restoration;
- relatively straightforward approval and contracting processes;
- flexibility, which allows projects to start small and then scale up through a process of replication; and,
- a growing community of project developers who are willing to share experiences and good practices.

Conclusion

The key weakness of the voluntary carbon market is its small size and lack of recognition by national governments and multilateral agencies. The sector needs to achieve scale and develop more credible governance structures. Above all, it needs to convince the international climate change community that the risk of project failure can be managed across a portfolio of activities. The climate change community for its part must accept the need to take on the risk of project failure – after all, if we do not even try then we are sure to fail.

I suggest that the UN agencies concerned with development, desertification, climate change and biodiversity should be much more proactive in engaging with the voluntary sector carbon initiatives for sustainable land use and forestry. At the very least, these activities can provide valuable lessons for the formal project mechanisms of the post-2012 climate change framework, and at most they could flourish into a major source of private sector engagement in sustainable land use in developing countries.

References

Brautigam, D. and K. Botchwey, 1999. *The Institutional Impact of Aid Dependence on Recipients in Africa.* Working Paper - Chr. Michelsen Institute no.1, pp. 1-39.

Dregne, H.E. and Nan-Ting Chou, 1992. “Global Desertification Dimensions and Costs” in Dregne, H.E. (ed.), *Degradation and Restoration of Arid Lands*. Texas Tech. University, Lubbock, Texas, USA, pp. 249-282.

de Jong, B., L. Soto-Pinto, G. Montoya-Gómez, K. Nelson, J. Taylor and R. Tipper, 1996. *Forestry and Agroforestry Land Use Systems for Carbon Mitigation: An Analysis from Chiapas, Mexico.* Proceedings of the Workshop on “Instruments for Global Warming Mitigation: The Role of Agriculture and Forestry”, Trento, Italy, 22 - 25 May, 1996. CAB International, UK, pp. 147-159.

Moss, T., G. Patterson and N. van de Walle, 2006. *An Aid-Institutions Paradox? A Review Essay on Aid Dependency and State Building in Sub-Saharan Africa*. Center for Global Development Paper No. 74.

[4]See: http://www.planvivo.org/.

Opportunities for Climate Change Mitigation in Agriculture: A Semi-Quantitative Assessment of Costs and Reductions Levels

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Abstract

Agriculture accounts for about 10-12% of the total global anthropogenic emissions of greenhouse gases (GHGs) or between 5.1 and 6.1 $GtCO_2e$ per annum. Emissions are increasing rapidly in agriculture, and between 1990 and 2005 these increases have been on the order of 17%. The objective of this paper is to assess the potential for climate change mitigation in the agricultural sector and to evaluate the costs of implementation of different options. In addition to examining the opportunities for emissions reductions, this paper examines the potential for creating sinks in agriculture and the costs of these options. There is potential for abatement of all sources, but with current technologies and the prevailing economic conditions, these potentials are all low. The analysis presented here suggests that 11-13% of non-CO_2 GHG and soil carbon emissions could be abated at reasonable costs. Sequestration, particularly through agroforestry, offers significant and cost effective means of reducing atmospheric concentrations of GHGs. The analysis suggests that the cost of sequestration could be as low as US$ 1.77 per tCO_2e, which is competitive with avoided deforestation and other forms of emissions abatement.

Introduction

Agricultural lands, comprising arable land, permanent crops and pasture, occupy about 40% of the earth's land surface (FAOSTAT[2]), and these lands are expanding. Most of the agricultural land is under pasture (~70%) and only a small percentage (<3%) are under permanent crops. Over the past four decades, an average of 6 million ha of forest and grassland has been converted to agriculture annually. Agricultural lands will continue to increase in the coming decades, with large increases expected in Latin America and Africa (Rosegrant et al., 2001). Emissions are expected to continue to increase due to increased demand for food as populations grow and with shifts in diets as societies in developing countries become wealthier and meat consumption increases.

There are two types of emissions from agriculture:

- Non-CO_2 GHGs from management operations = 6.2 Gt CO_2e
- Energy related CO_2 emissions (including emissions from manufacture of fertilizer) = 0.6 Gt CO_2e

Energy-related emissions are small from the sector, both in absolute magnitude and as a percentage of the emissions from the sector. They will not be considered further in this paper. Non-CO_2 GHG emissions are an order of magnitude greater than energy emissions. A third type of emissions from land-use change often associated with agriculture is also large, at around 7.6 Gt CO_2e.

In addition to reducing emissions from agricultural production, there are opportunities within the agricultural sector for additional measures to mitigate climate change. For example, there is a trend emerging for use of agricultural products to replace fossil-fuel based products, such as biomass energy, bio-plastics, and biofuels. This has the potential to reduce fossil-fuel emissions in the future, but emissions of non-CO_2 GHGs will increase, particularly as production systems intensify. Improved tillage practices have the potential to increase soil carbon storage and reverse the decline of soil carbon in newly converted lands. Thus, there is much interest in this practice both from the side of reducing energy use for tillage and for the potential for agricultural soils to be carbon sinks. In many cases however, infrequent tillage is practiced to control weeds, so the net long-term effects of this practice still needs to be evaluated.

Finally, although not considered in this report, changes in macroeconomic policy and regional patterns of production and demand lead to increased international trade in agricultural products. Increased transportation of agricultural products will lead to increased emissions.

1. Mitigation Potential and Costs

Mitigation potential in agriculture can be defined as either technical or economic. The technical potential for mitigation options in agriculture by 2030, considering all gases, is estimated at around 4500 Mt CO_2e by Caldeira et al. (2004). Smith et al. (2007) produced a higher estimate of between 5500 and 6000 Mt CO_2e. These estimates assume no economic barriers. The economic potential is, of course, considerably lower.

GHG emissions can be reduced by managing carbon and nitrogen more efficiently in agricultural ecosystems. Mitigation measures include agronomic measures such as improved crop varieties and different crop rotations. There are a series of soil management measures including improved nutrient management and reduced tillage that will reduce emissions and sequester carbon. Better residue and water management in rice can yield significant reductions of CH_4 emissions. For livestock, there are a wide range of practices associated with grazing, for example, land management, manure management and feeding that can reduce emissions and increase carbon sequestration. Finally, there are a number of changes in farming

[1]Currently with the Centre for International Forestry Research.
[2]Please see http://faostat.fao.org/.

systems that can contribute to GHG mitigation, including the production of biofuels to reduce the use of fossil fuels and the adoption of agroforestry or improved pasture management for carbon sequestration.

The United States Environmental Protection Agency (USEPA) constructed marginal abatement curves for different regions of the world (USEPA, 2006) and different sub-sectors by estimating the carbon price at which the present value benefits and costs for each mitigation option equilibrates (present value of benefits = present value of cost). This produced a stepwise curve that reflects the average price of a tonne of CO_2e and reduction potential if a mitigation technology were applied across the sector within a given region. Costs included capital, or one-time costs, and operation and maintenance costs, or recurring costs. The calculation included a tax rate of 40% and used a 10% discount rate. Benefits included the intrinsic value of CH_4 as either a natural gas or as fuel for electricity or heat generation, non-GHG benefits of abatement (e.g. improved nutrient use efficiency), and the value of abating the gas given a GHG price. The break-even price calculations do not include transactions costs. All calculations were in US$ from the year 2000. More details on the construction of these curves can be found in the report.

Most of the abatement curves indicate negative costs for some level of abatement (Table 1). This means that some GHG emission reduction is already feasible and cost-effective. These activities have not yet been implemented because there are non-monetary barriers that need to be overcome. These opportunities are often referred to as "no regret" options. The curves all become very steep or even vertical at around US$ 30-45 per tonne of CO_2e. Thus, for this analysis, we will assume that this is the maximum economic level of abatement and we will calculate the abatement potentials at this level.

There are two ways to calculate the global aggregate abatement curves for agriculture: one could hold the cultivated area and number of animals constant, or one could hold production constant. Regional abatement curves were generated as was a globally aggregated abatement curve. Both types of curves were used to generate the summary of net reductions at different carbon prices in different regions of the world that is presented in Table 1. The global estimate, holding cultivated area and the number of animals constant, is approximately 7% of the net emissions from agriculture that could be mitigated at a net benefit or at no cost (< $0/t$CO_2$e) in 2000. At higher C prices, the abatement potential rises. For example, around 14% of the net emissions can be mitigated for less than $45/t$CO_2$e. Beyond this point, costs rise rapidly. The greatest potentials for negative- and low-cost reductions are in the Russian Federation, the non-OECD (Organisation for Economic Co-operation and Development) Annex I countries and the United States, and the European Union (EU)-15. Moderate amounts of zero- or low-cost reductions are available in most other countries or regions, with the exception of Africa, Brazil, India, and Japan.

Table 1. Potential total reductions (MtCO_2e) of emissions from agriculture for selected countries and regions with carbon prices at US$ 0, 30 and 45 per tCO_2e, with constant cropping area and constant herd size. Table adapted from USEPA (2006).

	2010			2020		
Country/Region	$0	$30	$45	$0	$30	$45
Africa	5.8	13.1	16.4	6.0	15.1	22.4
Annex 1	136.5	222.6	234.4	140.1	210.1	258.4
Australia/New Zealand	7.3	10.4	12.7	7.7	11.3	13.7
Brazil	9.3	16.9	16.9	10.1	18.3	20.6
China	61.7	111.5	114.7	55.2	106.0	121.4
Eastern	7.2	9.7	9.9	7.1	10.2	10.8
EU-15	24.0	38.5	39.3	23.9	36.4	43.5
India	7.1	41.9	42.5	7.2	44.6	48.4
Japan	1.3	7.6	7.7	1.4	7.8	7.9
Latin America/Caribbean	12.1	15.5	16.7	13.6	18.6	20.4
Mexico	3.5	5.6	5.6	4.3	6.8	7.6
Non-OECD Annex 1	38.1	62.0	62.2	38.4	43.0	67.8
OECD	97.5	162.1	173.8	100.4	168.5	193.8
Russian Fed	36.6	60.5	60.7	37.0	41.5	65.4
S&SE Asia	71.6	115.4	138.5	82.6	131.1	163.3
United States	49.8	80.4	87.9	51.1	86.6	97.0
World	313.6	552.1	596.5	323.1	559.4	681.8

To evaluate the investment required for abatement of soil C and non-CO_2 GHGs, the mitigation scenario was determined by the abatement curves presented above. For a number of gases, the maximum economic abatement potential corresponded to between US$ 30-45 per MtCO_2e. For several other sources, it was clear that additional reductions were feasible, but generally beyond the level of US$ 45 per MtCO_2e the returns on the investment were decreasing rapidly.

Table 2 presents a sub-sector breakdown of the abatement opportunities and a projection through 2030. To project the reductions and the costs after 2020, which was the timeframe of the abatement curve analysis, the abatement curve for 2020 was used to calculate reductions and costs for 2030. Note that these curves assume constant harvested area and constant number of animals through time. Given the expected growth in population and the changes in diets to include more animal products as countries become more affluent, the estimates generated by this method are conservative. The projections for abatement costs range from US$ 16-20 billion (Table 2). Greatest reductions and greatest investments for these reductions are associated with mitigating emissions from rice. The smallest reductions and the smallest investments will be in the livestock sub-sector.

Table 2. Estimate of the reductions of emissions from non-CO_2 and soil carbon GHGs ($MtCO_2e$) and the investment needed to achieve these reductions ($ billion) between 2000-2030 at a cost of US$ 30 tCO_2e (2000).

	Year 2000		2010		2020		2030	
Sub-Sector	Reductions	Cost	Reductions	Cost	Reductions	Cost	Reductions	Cost
Cropland	172	7.74	183	5.48	168	5.04	180	5.39
Rice	200	6.00	226	6.79	238	7.14	243	7.30
Livestock	131	3.93	143	4.28	158	4.73	175	5.26
Total	529	15.88	596	17.89	631	18.92	684	20.51

2. Carbon Sequestration through Land Use Change and Management

The agricultural sector offers a number of mitigation opportunities, primarily through sequestration of atmospheric carbon, associated with land-use change and management. Agricultural lands also remove CH_4 from the atmosphere by oxidation, though less than forests, but this effect is small compared to other GHG fluxes (Verchot et al., 2000; Smith and Conen, 2004). Increased carbon stocks can be achieved through a change in land use to one with higher carbon stock potential (Lal, 2004; Albrecht and Kandji, 2003). The Intergovernmental Panel on Climate Change (IPCC) Special Report on Land Use, Land-Use Change and Forestry (2000) identified a number of categories of activities on agricultural lands that generate benefits:

- Agroforestry (including conversion from forests to slash-and-burn to agroforests after deforestation; conversion from low-productivity croplands to sequential agroforestry in Africa; integration of trees into farming systems and agricultural landscapes);
- Improved grassland management (including improved grazing management, fertilization, irrigation and use of improved species and legumes); and,
- Restoration of severely degraded lands (including salt-affected soils, badly eroded and desertified soils, mine spoils, and industrially polluted sites).

Two types of land management in the agricultural sector offer significant opportunities for carbon sequestration (Figure 1; IPCC, 2000): improved grassland management and agroforestry. For improved grasslands, high rates of sequestration can be achieved through introduction of more productive grass species and legumes. Improved nutrient management and irrigation can also increase productivity and sequester more carbon. About 60% of the grazing lands available for carbon sequestration are in non-Annex 1 countries.

Compared to other types of land-use change and compared to a number of management options, improved grazing land management and agroforestry offer the highest potential for carbon sequestration in non-Annex I countries. Agroforestry has such a high potential because it is the land use category with the second highest carbon density, after forests, and because there is a large area available for land use change. Grazing land management, despite the low carbon densities in these lands, has a high potential because of the large amount of land susceptible to this improvement (3.4 billion ha). Agroforestry also offers the potential for synergies between expanding the role of agroforestry in mitigation programmes and adaptation to climate change (Verchot et al., 2007). In many instances, improved agroforestry systems can reduce the vulnerability of small-scale farmers to inter-annual climate variability and help them adapt to changing conditions.

Other land use options, such as rehabilitation of degraded land and wetland restoration, have relatively low potentials, globally, to contribute to mitigation, although locally their potential may be significant. These low values are the combined result of low area availability and slow carbon accumulation rates.

A rigorous analysis of costs and mitigation potential does not presently exist in the literature and there is no basis to develop this at the moment. The IPCC (2000) Special Report presented an illustration of the potential of carbon sequestration to contribute to climate change mitigation. What I propose here is an expansion of the IPCC Special Report scenario, which will illustrate the potential for carbon sequestration in the agricultural sector and the costs of achieving that sequestration. The results of this analysis will only be semi-quantitative, but it is reasonable to expect them to be indicative of the order of the magnitude of the potentials and costs.

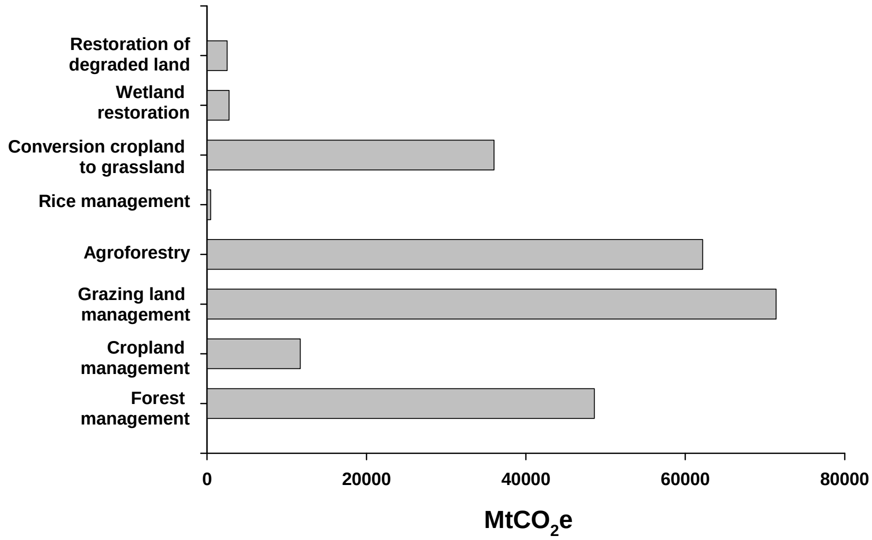

Figure 1. Technical potential for carbon sequestration of different land use and management options over a 30-year period (adapted from IPCC, 2000).

The IPCC scenario suggested that it would be possible, with considerable international effort, that 10% of the land available for improved pasture management could be under this improved management within 10 years and that as much as 20% could be under improved management within 40 years. Likewise, for agroforestry, the report suggested that 20% of the available land could be under this land management practice within 10 years and 40% within 40 years.

For this analysis, consider as an example a moderately intensive agroforestry system, which has been modelled using ENCOFOR (Environment and community based framework for designing afforestation, reforestation and revegetation projects in the CDM) decision support Carbon Model[3] (Figure 2). The system produces timber, with some food or cash crops grown in the understory. Examples of this system might be the rotational woodlots of Tanzania, the pine-coffee-banana systems of central Java, or the Eucalyptus and Poplar based agroforestry systems of the Indo-Gangetic Plain (Bekele-Tesemma, 2007).

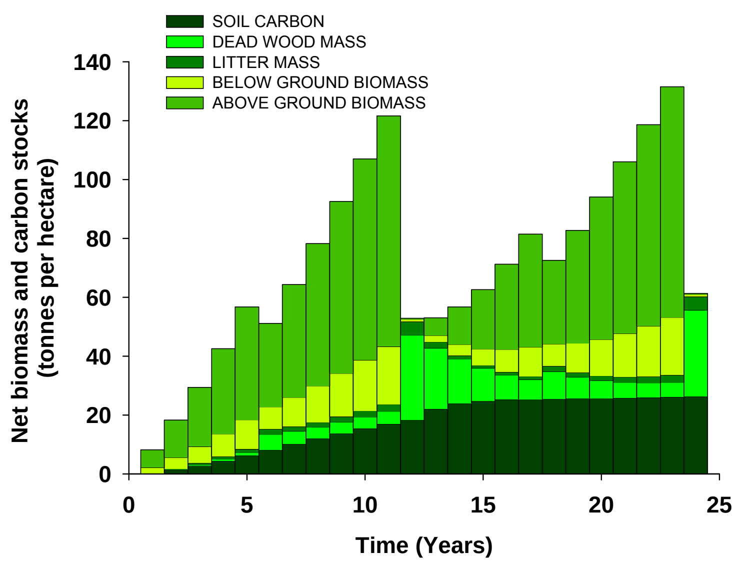

Figure 2. Projection of carbon accumulation in a multi-strata agroforestry system, generated using the ENCOFOR decision support Carbon Model[4].

In this system, the trees are harvested after 12 years and regenerated. The ENCOFOR model suggests that the average annual accumulation in this example over 30 years is 1.26 tonnes C per ha, and over 60 years this average figure drops to 0.52 tonnes per ha per year. The IPCC Special Report suggested an average carbon accumulation rate in an agroforestry system was about 3.1 tonnes per ha for a 30 to 50-year time horizon. These values are appropriate for a multi-strata system

[3]Please see http://www.joanneum.at/encofor.
[4]Available at http://www.joanneum.at/encofor.

that is kept in place over a long period of time, such as the home garden systems of Africa or the jungle rubber agroforestry systems of Indonesia.

These two examples are used because they provide useful bounds to our calculations. In one case we have a system which is regularly harvested and therefore has lower annual accumulation rates because the aboveground biomass is regularly brought back to zero. In the other case, we have a permanent tree-based farming system.

Carbon sequestration potential can be calculated by taking the time frame proposed in the IPCC Special Report, taking the projections of area of land adopting the improved practices, and using both the IPCC and ENCOFOR projections for carbon accumulation rates, and the IPCC projection for grassland management. Table 3 presents the scenarios for agroforestry and grassland management. If we take the sum of the annual accumulation rates over the next 30 years, the results suggest that the total potential sequestration is on the order of 12 to 19 Gt of carbon or 45 to 70 Gt of CO_2e. This does not account for the carbon sequestered in harvested wood products from the agroforestry plantations.

Table 3. Estimates of C sequestration in agricultural lands for the two practices with the highest potential over 30 years. Two scenarios are presented for agroforestry, one based on the IPCC (2000) LULUCF report and one based on the projections of the ENCOFOR Carbon Model. The time period for the analysis is 30 years.

			Permanent agroforestry (IPCC)		Rotational agroforestry (ENCOFOR)	
Time (years)	Land area available (M ha)	Adoption/ conversion of area (%)	Rate of C gain (tC ha^{-1} y^{-1})	Carbon (Mt y^{-1})	Rate of C gain (tC ha^{-1} y^{-1})	Carbon (Mt y^{-1})
Agroforestry						
10	630	20	3.1	391	1.26	159
20		27		521		212
30		33		651		265
Grassland management						
10	3,400	10	0.7	238		
20		13		317		
30		17		397		

To begin to evaluate the investments required to achieve these levels of carbon sequestration, I will continue with the agroforestry example developed above. To calculate these costs, the ENCOFOR financial analysis tool was used and two rotations were analyzed. Costs of tree planting projects were calculated on a hectare basis and include those associated with plantation establishment (~US$ 780), maintenance costs like weeding and pruning (~US$ 440), costs for measurement and monitoring of the carbon sequestered (~US$ 190) and preparation of documentation for crediting carbon (~US$ 60). In many cases, extension and farmer education is required to teach farmers about new agroforestry systems. The total cost in this scenario is US$ 1470 per ha. From the example above, an agroforestry plantation contains an average 80 tonnes of biomass over its lifetime or 40 tonnes of C per ha in 5 carbon pools (aboveground biomass, belowground biomass, deadwood, litter, and soil carbon). The costs of establishment and maintenance of these plantations amounts to US$ 36.75 per tonne of carbon, or US$ 10.02 per tonne of CO_2e.

Not all of these costs need to be borne by the international community or by outside investors. Agroforestry systems are profitable in their own right. The example given here has a 22% internal rate of return. Agroforestry systems vary considerably across regions and have varying income generation potential. Costs can be shared with rural farmers who will benefit from these profitable systems. In most cases agroforestry systems are more profitable than subsistence agriculture. The idea of additionality in financing carbon sequestration is already embodied in the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. Additionality is the criteria for carbon offset projects to determine offsets that occur in addition to business as usual. Additionality is determined by analyzing barriers.

There are numerous barriers to adopting improved agroforestry systems, including delayed returns on investment, lack of knowledge and labour shortages. In this case, we consider only the financial barrier due to negative cash flow over the first three years of the plantation. Investments of US$ 640 per ha would be required to overcome this and thus the cost of sequestering the carbon would be only US$ 16 per tonne of carbon or US$ 4.36 per tCO_2e. For the case of permanent agroforestry, assuming similar establishment and operating costs, the cost per tonne is around US$ 1.77 because of the higher productivity of the system.

Finally, to put this in a global perspective, the technical potential C sequestration of this scenario is 30.8 $GtCO_2$e for a total cost of US$ 134.4 billion. The actual potential suggested by the IPCC scenario is given in Table 4. Greater consideration of these land-use mitigation options is warranted, as these types of activities can offer multiple benefits. If well designed, agroforestry, grassland management, land rehabilitation, and wetland rehabilitation projects can contribute to biodiversity conservation, watershed protection, reduction of desertification, sustainable land management and poverty reduction (Verchot et al., 2007).

Table 4. Calculations of actual sequestration potential and costs for agroforestry using the IPCC (2000) scenario for adoption/conversion. Costs are calculated using total costs per hectare and the values suggested for investments aimed at removing barriers only.

		Sequestration potential		Implementation costs	
Time (years)	Adoption/ conversion of area (%)	Permanent agroforestry ($MtCO_2e\ y^{-1}$)	Rotational Agroforestry ($MtCO_2e\ y^{-1}$)	Full ($M)	Barriers only ($M)
10	20	1,434	583	5,843	2,544
15	23	1,672	682	6,836	2,976
20	27	1,910	777	7,791	3,392
25	30	2,149	876	8,783	3,824
30	33	2,387	972	9,739	4,240

Conclusion

There are many opportunities for mitigating non-CO_2 GHG and soil carbon emissions in agriculture. Emissions can be reduced by managing carbon and nitrogen more efficiently in agricultural ecosystems. There are opportunities for small emissions reductions at a net benefit or at zero cost, and these need to be pursued. There is potential for abatement of all sources, but with current technologies and the prevailing economic conditions these potentials are all low. The analysis presented here suggests that 11-13% of non-CO_2 GHG and soil carbon emissions could be abated at reasonable costs.

The analysis presented here shows that sequestration offers significant and cost-effective means of reducing atmospheric concentrations of GHGs. There are large potentials in a number of practices in agriculture. In the examples worked out in this report on agroforestry, total costs for sequestration were on the order of US$ 10 per tCO_2e and the estimates of global feasibility are between 0.7 and 2.1 $GtCO_2e$ per year. Many of these practices are economically beneficial, but do not occur due to a number of barriers. Investment targeted at overcoming these barriers is much less than the total cost, and therefore, there are opportunities to share costs with other beneficiaries. The analysis suggests that the cost associated with overcoming these barriers is less than US$ 4.50 per tCO_2e and perhaps as low as US$ 1.77 per tCO_2e.

References

Albrecht, A. and S.T. Kandji, 2003. “Carbon Sequestration in Tropical Agroforestry Systems” in *Agriculture, Ecosystems and Environment,* 99, pp.15-27.

Bekele-Tesemma, A., 2007. *Profitable Agroforestry Innovations for Eastern Africa*. RELMA World Agroforestry Centre, Nairobi, Kenya.

Caldeira, K., M.G. Morgan, D. Baldocchi, P.G. Brewer, C.T.A. Chen, G.J. Nabuurs, N. Nakicenovic and G.P. Robertson, 2004. “A Portfolio of Carbon Management Options” in Field, C.B. and M.R. Raupach (eds.), *The Global Carbon Cycle. Integrating Humans, Climate, and the Natural World*. SCOPE 62, Island Press, Washington DC, pp.103-129.

Intergovernmental Panel on Climate Change (IPCC), 2000. *IPCC Special Report on Land Use, Land-Use Change and Forestry*. Cambridge University Press, Cambridge.

Lal, R., 2004. “Soil Carbon Sequestration Impacts on Global Climate Change and Food Security” in *Science*, 304, pp. 1623-1627.

Rosegrant, M., M.S. Paisner and S. Meijer, 2001. *Long-Term Prospects for Agriculture and the Resource Base*. The World Bank Rural Development Family. Rural Development Strategy Background Paper #1. Washington, D.C.

Smith, K.A. and F. Conen, 2004. “Impacts of Land Management on Fluxes of Trace Greenhouse Gases” in *Soil Use and Management*, 20, pp. 255-263.

Smith, P., D. Martino, Z. Cai, D.Gwary, H.H. Janzen, P. Kumar, B. McCarl, S.Ogle, F. O’Mara, C. Rice, R.J. Scholes, O. Sirotenko, M. Howden, T. McAllister, G. Pan, V. Romanenkov, U. Schneider, S. Towprayoon, M. Wattenbach and J.U. Smith, 2007. “Greenhouse Gas Mitigation in Agriculture” in *Philosophical Transactions of the Royal Society* (B).

US Environmental Protection Agency (USEPA), 2006. *Global Mitigation of Non-CO_2 Greenhouse Gases*. Washington DC: USEPA.

Verchot, L.V., E.A. Davidson, J.H. Cattânio and I.L. Ackerman, 2000. “Land-use Change and Biogeochemical Controls of Methane Fluxes in Soils of Eastern Amazonia” in *Ecosystems*, 3, pp.41-56.

Verchot, L.V., M. van Noordwijk, S. Kandji, T. Tomich, C. Ong, A. Albrecht, J. Mackensen, C. Bantilan, C.K. Anupama and C. Palm, 2007. “Climate Change: Linking Adaptation and Mitigation through Agroforestry” in *Mitigation and Adaptation Strategies for Global Change*, 12, pp.1381-2386.

Can Iceland Become a Carbon Neutral Country by Reducing Emissions and Restoring Degraded Land?

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Introduction

Mitigation of human-induced changes to the earth´s climate is among the most pressing challenges of the next decades. Reducing emissions of greenhouse gases (GHG) and returning some of the CO_2 back into the earth for storage in soil and vegetation are both essential tools if countries are to become carbon neutral with regards to the GHG emissions.

Being carbon neutral refers to reducing one's own GHG emissions as far as possible and to offset the remaining emissions by other activities (see Figure 1). This concept is fairly new and refers to a voluntary action taken by countries, companies or individuals, without any legal requirements, setting emissions reduction targets well beyond targets set by international agreements such as the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. Becoming carbon neutral is a new way of thinking. The Vatican is presently the only carbon neutral state; Costa Rica aims to reach this by 2030 and Norway by 2050 (Dobles, 2007; Norwegian Ministry of Finance, 2007; Planktos/KlimaFa, 2007).

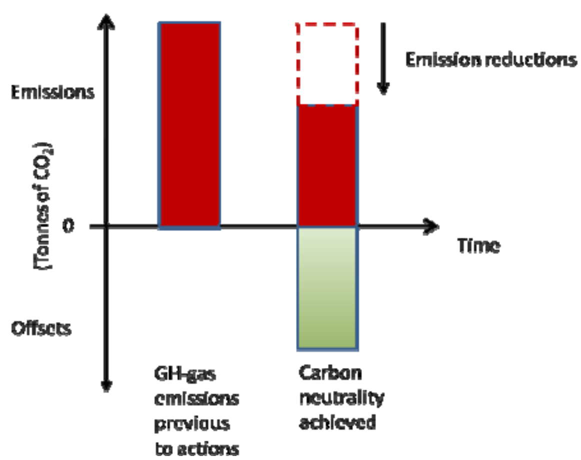

Figure 1. Carbon neutrality refers to reducing greenhouse gas emissions to the atmosphere as much as possible and to offsetting the remaining emissions by other activities (Ágústsdóttir, in press).

1. The Icelandic Profile

Iceland offers a good example of a country which could become carbon neutral within a few decades by combining emission reductions with mutually beneficial land restoration on vast areas in Iceland that have become degraded over the last millennium.

Iceland is responsible for about 0.01% of global greenhouse gas emissions, reflecting its small population of only about 300,000 people (UNFCCC, 2007). The country's emissions profile is unique in three ways: 1) the high proportion of renewable energy (70%) of the total amount of energy used; 2) emissions from the fishing fleet is about one-fourth of the total emissions; and 3) individual sources of industrial process emissions have a significant proportional impact at the national level due to the small size of the economy (Icelandic Ministry for the Environment, 2006).

The governmental climate strategy from 2007 contains the long-term goal of cutting net emissions in Iceland by 50-75% by 2050 (Icelandic Ministry for the Environment, 2007). That goal, or even more ambitiously, carbon neutrality, will only be reached with a concerted action from every sector. The Icelandic strategy contains rough estimates of emissions in 2005 of seven key sectors (Icelandic Ministry for the Environment, 2007): energy production (4% of total emissions); industrial processes (25%); the fishing fleet (19%); agriculture (13%); waste (5%); transport (20%); and industrial fossil fuel use (11%). The carbon-efficiency and mitigation potential of these sectors vary.

2. Emissions from Different Sectors

The potential for emission reduction varies greatly between the key emissions sectors in Iceland. Discussion on the three largest sectors follows below.

Transport is probably the least carbon-efficient sector in Iceland, and hence a priority for policy changes aimed at emission reductions. The potential for reducing emissions in this sector is seen as moderate in the short-term and significant in the long-term (UNFCCC, 2007). The state of transportation affairs cannot be considered climate friendly, according to a survey conducted in 2002 on transport in the Reykjavík capital area where 70% of the national population resides. At the time, private cars were used in 76% of all transport, walking/bicycling in 19%, and public transport in 4%. This leaves considerable potential for improvement, such as by increasing public transport and building a better network of bicycle and walking trails. The Ministry of Finance announced in September 2007 that it is revising the tax system on fuel and vehicles in order to promote the reduction in greenhouse gas emissions and the use of low-emission and alternative fuel vehicles (Icelandic Ministry of Finance, 2007b). The capital city of Reykjavík provides free parking spaces for certain defined clean or low-emission vehicles (Reykjavík City Council, 2007). Several towns in Iceland have offered free public transport (buses) to everyone, while others provide only high school and university students with this service, including the capital area (Reykjavík City Council, 2007). This has greatly increased the number of passengers using public transport. All of these initiatives are part of a progress towards a low-carbon society, but more changes are needed to reduce emissions in the transport sector, including changes on tax policies and economic incentives.

The fishing fleet in Iceland is responsible for about 19% of national emissions, reflecting the country's status as the 12th largest fishing nation in the world. Mitigation potential is seen as low in the short-term compared to that of other developed countries due to the fact that the Icelandic fishing industry is not subsidized, unlike those in many neighbouring countries (UNFCCC, 2007). Alternative fuels for ships may not be an option in the near future; however, there are possibilities of immediate emission reductions. Energy management systems can help minimize fuel consumption, and savings of up to 12% have been reported. More improvements are expected in the future (Marorka, 2007). Also, making shore-side power available to ships would limit the use of fossil fuels when in harbour, as electricity is produced by renewable energy in Iceland.

Industrial processes in Iceland are responsible for about 25% of national emissions, and the reduction potential is estimated to be low (UNFCCC, 2007). One example of possible reduction might be that fossil fuels used in the industrial production of fish meal could be replaced by electricity, reducing emissions from 122 Gg CO_2 (3.3% of total) to zero. In the aluminium industry, emissions of greenhouse gases per tonne of produced aluminium have been reduced by more than two-thirds since 1990, and are currently only about 35% of the global average, counting both energy- and process-related emissions. The potential for further reduction is therefore seen as low, as this industry in Iceland is possibly the most carbon-efficient in the world. New technologies that are being studied, like carbon-free anodes in aluminium production, could significantly reduce emissions in the future, but are not feasible at present (UNFCCC, 2007). Despite a highly carbon-efficient aluminum industry, emissions from it are expected to increase in the future as further growth of this sector in Iceland is expected due to plentiful and low-cost energy.

3. The Potential for Sequestration

In addition to reducing emissions in Iceland, there is a large potential for sequestering carbon into soil and vegetation. Iceland provides a good example of the multiple roles of carbon sequestration in reaching important environmental, social and economic goals (Arnalds, 2004; Ágústsdóttir, in press). Revegetation is defined in the Kyoto Protocol as a direct human-induced activity initiated after 1990 to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 ha but does not meet the UNFCCC definitions of afforestation and reforestation. Revegetation is largely regarded as a win-win strategy, restoring soil fertility and land quality, strengthening ecosystem services, conserving and restoring biological diversity, increasing food security and mitigating climate change. Revegetation in Iceland refers to reclaiming vegetation on barren or severely damaged land that needs external or human input to overcome ecological thresholds. The goal is to recreate an ecosystem that will naturally regenerate in the future.

The potential of the soils in Iceland for carbon sequestration is high because of its unique composition. Icelandic soils are exclusively from two soil orders, Andosols (54%) and Histosols (6.7%) (Arnalds and Grétarsson, 2001). Of all soil orders, these two store the most C per unit area, with mean global values of 31 and 218 kg m^{-2} for Andosols and Histosols, respectively (Batjes, 1996). The difference between soils of barren areas, with <1 kg C m^{-2} and fully vegetated undisturbed Andosols with >40 kg C m^{-2}, indicates that reclamation of degraded sites may have a high potential for carbon sequestration, which may last for a long time until the system reaches a saturated carbon balance (Arnalds et al., 2000).

The carbon sequestration potential on a national scale is demonstrated by the enormous soil erosion Iceland has suffered since the time of its settlement. Areas with considerable to extremely severe erosion cover about 40% of the country (Arnalds et al., 2001). In an assessment of barren lands in Iceland, Óskarsson et al. (2004) estimated that between 120 and 500 million tonnes of organic carbon has been lost from Icelandic soils during eleven centuries of human settlement, approximately half of which have been oxidized and lost to the atmosphere. Accounting for degradation of soil and vegetation outside the assessed areas, the total carbon losses rest higher.

In 2005, carbon sequestration due to revegetation amounted to 533 Gg CO_2 or 14.4% of total emissions excluding LULUCF, or 9.7% of total emissions including LULUCF (Hallsdóttir et al., 2007). These carbon offsets can be increased significantly, as there is an urgent need to return some of the lost carbon back to the land, recharging the ecosystems. With the current rate of revegetation projects initiated since 1990, carbon sequestration could easily reach 1000 Gg CO_2 in 2020. The potential is however much greater since such large areas of the country are suffering from severe erosion and poor land health. A combination of revegetation, afforestation and wetland restoration as climate change mitigation activities could provide important leverage for Iceland's GHG budget.

Carbon sequestration is a method of emissions reduction that is immediately available using technology developed by nature itself. Early action increases the likelihood of avoiding the most severe consequences of global climate change according to the findings of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report: Climate Change Mitigation (IPCC, 2007). No one method of emissions reduction will be a sole solution for climate mitigation. The use of various options in different sectors is needed in a concerted action to achieve this aim, and carbon sequestration can be one important means to that end.

Although carbon sequestration by revegetation and reducing emissions are two different routes to the same goal, many environmental groups see this as an escape route for countries to reduce emissions. Therefore, the overall quality and benefits of such projects must be mutually supportive to the overall goals of the Multilateral Environmental Agreements, and with an emphasis on verifiability and permanency of the carbon sequestered.

4. Examples of Activities Resulting in Carbon Storage in Iceland

Financing revegetation is relatively cheap compared to other more expensive, experimental, high-technology projects for removing carbon from the atmosphere. Financial assistance, incentives and disincentives are important for stimulating land improvement. What follows is a description of some of the practices currently in use or possibilities that could be employed regarding increasing carbon sequestration in soil and vegetation in Iceland.

Regulation on land use: It is important to increase sustainability of land use on both common and private lands in Iceland. This would aid in both preventing further carbon losses through land degradation and in stimulating carbon storage through recovery of vegetation and soils. In the year 2000, the Icelandic government and sheep farmers signed a contract on agricultural support which has partial cross-compliance, i.e. about one-third of the support is dependent on the quality of land use. The subsidy agreement was then revised and renewed in 2007. Participation is on a voluntary basis, but farmers that meet the quality criteria receive up to 22.5% more subsidies in government support. The main criteria on the use of land for grazing is that the condition of the land shall be acceptable, and the state of vegetation stable or improving. Farmers not meeting the criteria have to submit land quality improvement plans. This cross-compliance scheme is resulting in both avoidance of carbon losses from land degradation, and a direct increase in carbon sequestration.

Farmers Heal the Land Programme: Within this incentives programme for better land health that has been operating since 1990, the Soil Conservation Service of Iceland (SCS) now assists about 20% of Icelandic farmers to revegetate degraded land, to halt erosion, and to reclaim land for grazing and other agricultural purposes. The SCS provides consultation and seeds (if needed) and partially refunds the cost of fertilizer; farmers take care of seeding, fertilizing and transport costs.

Land Improvement Fund ('Landbótasjóður'): This is another example of a programme aimed at improving better land health which also leads to increased carbon sequestration. It was established in 2003 with the purpose of moving responsibility, initiative and execution of soil conservation projects to local authorities, land owners, local governments, communities and non-governmental organizations by providing funding for soil conservation and land restoration projects that might not be applicable to the framework of the Farmers Heal the Land Programme. The SCS provides consultation, funding and supervision of projects. Projects that conform to the aims and focal points of long-term soil conservation strategy planning for 2003-2014 are given priority.

Afforestation: Afforestation of treeless landscapes results in a net carbon sequestration in biomass (e.g. IPCC, 2000; Snorrason et al., 2002). The woodland cover in Iceland in 1990 was 1% of land area (Icelandic Ministry for the Environment and Icelandic Institute of Natural History, 2001). In 2005, sequestration due to forest amounted to 126.27 Gg CO_2, or 3.4% of total emissions that year (Hallsdóttir et al., 2007).

There are plans for increasing forest cover and associated carbon sequestration considerably. In the most recent forestry-related legislation, the future goal is set to increase woodland and forest cover to at least 5% of the lowland surface area below the altitude of 400 m during the next 40 years (Althingi, 2006). This 5% goal is expected to reach a maximum sequestration of 1.3 million tonnes CO_2 yr^{-1} (or 1300 Gg CO_2 yr^{-1}) in 2040 (Snorrason, 2006).

Restoration of wetlands: Extensive drainage of wetlands occurred in Iceland in the period 1945-1990, due to subsidy programmes by the government. During this period, approximately 4,500 km^2 (60-75%) of all lowland wetland areas were drained for cultivation purposes (Icelandic Ministry for the Environment and The Icelandic Institute of Natural History, 2001; Óskarsson, 1998). In the lowlands, only a few areas remain intact.

Research has shown that reclaimed wetlands can sequester carbon, while drained wetlands are big emitters of CO_2 (Icelandic Ministry for the Environment, 2006). These drained wetlands currently emit about 1.8 million tonnes CO_2 per year (or 1800 Gg CO_2 yr^{-1}, calculated using UNFCCC default emission factors (IPCC, 2003)). A typical undisturbed wetland in Iceland sequesters about 51-99 tonnes CO_2 per km^2 yr^{-1} (H. Óskarsson 2007, personal communication).

Conditions for wetland restoration in Iceland are considered favourable as most of the drained wetlands have not been intensively cultivated or excavated. They still have semi-natural vegetation that is relatively rich in wetland species. In most cases, establishment of suitable hydrological conditions should be sufficient for the restoration of mires and other wetland areas (Icelandic Ministry of Agriculture, 2006). Today, only about one-eighth of drained wetlands are currently being used as agricultural land, mainly as hayfield and pasture, leaving much room for wetland restoration (H. Óskarsson 2007, personal communication). If only half of the drained wetlands were to be restored, then their present carbon budget emission of 0.9 million tonnes CO_2 yr^{-1} could be turned into sequestration of approximately 0.12-0.22 million tonnes CO_2 yr^{-1} (or 120-220 Gg CO_2 yr^{-1}).

Restoration of wetlands is a priority area of the government's long-term climate mitigation planning (Icelandic Ministry for the Environment, 2002, 2007), but an action plan and funding have not been developed.

Other voluntary carbon offsets: Many individuals and companies are willing to volunteer funding, either due to their climatic conscience or for the purpose of presenting a good corporate responsibility related to environmental concern. 'Kolviður', The Iceland Carbon Fund, was founded by the Icelandic Forestry Association and the Icelandic Environment Association and is sponsored by the Government of Iceland, Reykjavík Energy and Kaupthing Bank. It is a carbon offsetting company that facilitates carbon sequestration through afforestation. This effort has definitely put carbon offsets on the map in Icelandic society. Projects on a national offset scale need organization, careful species selection and the consideration of multiple benefits for society.

Carbon sequestration with geological processes: In addition to reducing emissions into the atmosphere and sequestering carbon in soil and vegetation there is the possibility of sequestering carbon with geological processes or chemical weathering. One environmental impact of geothermal production is the emission of gases, such as CO_2, into the atmosphere. Wells already drilled for the reinjection of liquid have been made available by Reykjavík Energy at Hellisheiði in Iceland for mineral sequestration studies in an attempt to devise new ways of disposing of CO_2. A possible means of storing CO_2 underground is to use chemical bonding of injected CO_2 in a mineral phase. Igneous rocks such as basalt provide the medium to effect the precipitation of carbonate minerals from injected CO_2-saturated fluids (Matter et al., 2007). Upon injection into basalt aquifers, CO_2 will acidify the groundwater and the acid will be neutralized by water-rock reactions. Results of these studies will hopefully provide means of disposal of CO_2 by sequestration in basalts.

5. Can Carbon Neutrality Be Achieved?

The global process of climate change will influence ecological, economic and social activities and development at the regional and local level in all countries, making it one of the more profound challenges to sustainable development and poverty eradication.

Whether the goal of carbon neutrality will be achieved depends very much on the current and future political and financial environment. Generally, the political horizon (months to years) is quite short compared to that for climate issues (years to decades), which, again, affect decision patterns on policy issues. Politics are very much influenced by societal views and pressures when acting upon climate mitigation. In recent years, climate issues have gained higher visibility at the international and national scales. Increased pressure is coming from the public, NGOs and other vested interest groups, along with peer pressure within sectors and between companies. This increased interest in climate mitigation may affect the priority placed on environmental/climate issues in national politics and subsequently affects available funds for mitigation actions.

The legal basis and requirements for emissions reduction in Iceland is currently weak. No laws or regulations cover the commerce of carbon credits and thus no national carbon market is in place. Presently, this prevents land users and large-scale emitters from cooperating towards lowering emissions of greenhouse gases through carbon sequestration, and therefore needs to be remedied.

With its renewable energy resources, actively employing new climate-friendly technology, the vast potential for carbon sequestration by the restoration of degraded land, restoration of wetlands, forestry and more sustainable use of land, Iceland may have the option of becoming a carbon neutral country much sooner than anticipated in the current governmental strategy.

References

Ágústsdóttir, A. M., in press. "Using Soil Carbon Sinks to Make a Nation Carbon-neutral" in Lal, Rattan (ed.), *Encyclopaedia of Soil Science*, 3rd edition.

Althingi, 2006. *Lög um landshlutaverkefni í skógrækt* [Laws on Regional Afforestation Programmes], pp. 3. Available at: http://www.althingi.is/altext/132/s/pdf/1373.pdf.

Arnalds, A., 2004. "Carbon Sequestration and the Restoration of Land Health" in *Climate Change*, 65(3): 333-346.

Arnalds, O., G. Guðbergsson and J. Guðmundsson, 2000. "Carbon Sequestration and Reclamation of Severely Degraded Soils in Iceland" in *Icelandic Agricultural Sciences*, 13, pp. 87-97.

Arnalds, O., E.F. Thórarinsdóttir, S. Metúsalemsson, A. Jónsson, E. Grétarsson and A. Árnason, 2001. *Soil Erosion in Iceland*. Soil Conservation Service, Agriculture Research Institute, Reykjavík, Iceland. (English translation, originally published in Icelandic in 1997).

Arnalds, Ó. and E. Grétarsson, 2001. *Soil Map of Iceland*. 2nd edition. Agricultural Research Institute (RALA), Reykjavík, Iceland.

Batjes, N.H., 1996. "Total Carbon and Nitrogen in the Soils of the World" in *European Journal of Soil Science*, 47, pp. 151-163.

Dobles, R., 2007. "Agenda for Action" in *Our Planet, The Magazine of the United Nations Environment Programme (UNEP)*, 5, pp. 10-11. Available at: http://www.unep.org/pdf/Ourplanet/2007/may/en/OP-2007-05-en-FULLVERSION.pdf.

Hallsdóttir, B.S., R. Kamsma and J. Guðmundsson, 2007. *National Inventory Report, Iceland 2007*. Submitted under the United Nations Framework Convention on Climate Change. Umhverfisstofun (Environment and Food Agency), Reykjavík, Iceland, pp. 185.

Icelandic Ministry for the Environment, 2002. *Welfare for the Future: Iceland's National Strategy for Sustainable Development 2002–2020.* Reykjavík, Iceland, pp.83.

Icelandic Ministry for the Environment, 2006. *Iceland's Fourth National Communication on Climate Change Under the United Nations Framework Convention on Climate Change and Iceland's Report on Demonstrable Progress Under the Kyoto Protocol*, pp. 74.

Icelandic Ministry for the Environment, 2007. *Iceland's Climate Change Strategy. Long-term vision 2007-2050*, pp. 37.

Icelandic Ministry for the Environment and the Icelandic Institute of Natural History. 2001. *Biological Diversity in Iceland. National Report to the Convention on Biological Diversity*, Reykjavík, pp.56.

Icelandic Ministry of Agriculture, 2006. *Endurheimt votlendis 1996-2006. Skýrsla votlendisnefndar*. Reykjavík, Iceland, pp 15. (In Icelandic.)

IPCC, 2000. *Land Use, Land-use Change, and Forestry. A special report of the Intergovernmental Panel on Climate Change (IPCC)*. Watson, R.T., I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo and D.J. Dokken, (eds.). Cambridge University Press, Cambridge, pp. 377.

IPCC, 2003. *Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF)*. Penman, J., M. Gytarsky, T. Hiraishi, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe and F. Wagner, eds. Intergovernmental Panel on Climate Change (IPCC), IPCC/IGES, Hayama, Japan.

IPCC, 2007. *IPCC Fourth Assessment Report, Working Group III Report on Mitigation of Climate Change*.

Marorka, 2007. *Marorka*, http://www.marorka.is/

Matter, J.M., T. Takahashi and D. Goldberg, 2007. "Experimental Evaluation of *in situ* CO_2-water-rock Reactions during CO_2 Injection in Basaltic Rocks: Implications for Geological CO_2 Sequestration" in *Geochemistry Geophysics Geosystems*, 8.

Norwegian Ministry of Finance, 2007. *Carbon Neutral Norway. Ministry of Finance Carbon Scheme*, http://www.regjeringen.no/en/dep/fin/campaign/Carbon-Neutral-Norway/Home-Carbon-Neutral-Norway.html?id=479475.

Icelandic Ministry of Finance, 2007. *Vefrit fjármálaráduneytisins*, 27 September 2007, http://www.fjarmalaraduneyti.is/media/FJR.IS/Vefrit_fjr_270907.pdf. (In Icelandic).

Óskarsson, H., 1998. "Framræsla votlendis á Vesturlandi" in (Ólafsson, J.S., ed.), *Íslensk votlendi - verndun og nýting*. Háskólaútgáfan, Fuglavernd og Líffræðifélag Íslands, pp. 121-129.

Planktos/KlimaFa, 2007. *Vatican to Become World's First Carbon Neutral Sovereign State. Planktos/KlimaFa's New Vatican Climate Forest Initiative to Fully Green the Holy See*. Available at: http://www.planktos.com/Newsroom/VaticanbecomesWorldsFirstCarbonNeutralSovereignState.html.

Reykjavík City Council, 2007. Available at: http://www.reykjavik.is/ (In Icelandic).

Snorrason, A., B.D. Sigurdsson, G. Gudbergsson, K. Svavarsdóttir and T.H. Jónsson, 2002. "Carbon Sequestration in Forest Plantations in Iceland" in *Icelandic Agricultural Sciences*, 15, pp. 81-93.

Snorrason, Á., 2006. "Langtímaspá um kolefnisbindingu nýskógræktar" in *Skógræktarritið (Journal of the Icelandic Forestry Association)*, 2, pp. 58-64. (In Icelandic).

UNFCCC, 2007. *Addendum 1: Information and Views on the Mitigation Potential at the Disposal of Annex I Parties. Submissions from Parties*. Ad Hoc Working Group On Further Commitments for Annex I Parties Under The Kyoto Protocol. Third Session, Bonn, 14–18 May 2007. Available at: http://unfccc.int/resource/docs/2007/awg3/eng/misc01a01.pdf.

Session 4:
Creating an Enabling Environment

Our Covenant with Earth: The Contribution of Soil Ethics to Our Planetary Future

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"I am the Living Earth, I am the softened tissue of rocks, baked by the sun, split by ice, carried by water, and winnowed by the wind. I am interwoven by myriads of tiny plants and animals that pulse and breathe. I am the invisible universe of sparkling molecules in the infinity of living soils that bless the mantle of the globe." – Len Webb

"That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics." – Aldo Leopold

Introduction

Soil health is one of the most critical, if neglected, components in the well-being of the biosphere and the human civilizations that depend upon it. Our readiness to assume responsibility for it must be considered an essential part of the movement to create a new global covenant committed to universal principles of sustainability, justice and peace.

This paper argues for six basic ways in which soil ethics can contribute to the making of the Earth covenant. These are: (1) land care as exemplary of the necessity of addressing the environmental and social issues of our planet together; (2) soil integrity as the *sine qua non* of ecological and biospheric integrity; (3) the nature and role of soil 'stewardship' in the covenants we make between the generations; (4) the need for precaution in the ways we treat soil, given the limits of our scientific and practical understanding of how to preserve and restore it; (5) the need to take a 'common but differentiated' approach to our cultural as well as economic and technological capacities for land care; and (6) the evolutionary and spiritual solidarity we experience with the Earth through soil.

1. Making the Earth Covenant

1.1. Calls for a new Earth covenant

Over the course of the last several decades, calls for a new Earth covenant have come from all quarters of the globe (Engel, 2004). Sometimes the call is for a 'new global compact', a term used by United Nations Secretary-Generals Javier Perez de Cuellar and Kofi Annan. But more prophetically and accurately, in the words of liberation theologian Leonardo Boff and political philosopher David Held, it is a call for 'a new covenant with Earth'. These calls presume that we are citizens of the world as well as of nations, that we live in an interdependent planetary community and that if we are to overcome the tragedy of the global commons we must reach agreement on the fundamental moral principles of global governance.

Covenants are open, unconditional commitments to be faithful to others regarding our most fundamental values and behaviours, and they have historically served as the spiritual and moral authority for national constitutions and international treaties. Covenant and compact are often used interchangeably to describe public agreements of unlimited duration that require mutual consent to be abrogated, but covenant typically places primary emphasis on the moral dimension, while compact on the legal. Both need to be distinguished from contracts, which are limited agreements for the sake of a utility of direct benefit to the consenting parties and which are dissolved once that utility is obtained. Calls for a new Earth covenant or compact recognize that to address issues as daunting as climate change we need not only new and better contracts, but a transformation in our personal and collective loyalties.

1.2. The Earth Charter and the proposed Soil Charter

Officially launched in The Hague in 2000, the Earth Charter[1] is the most complete public statement we have yet of the moral and spiritual vision of a new Earth covenant. As a people's treaty circulated throughout the world, with endorsements by hundreds of NGOs, municipalities, national governments and international agencies, it is the most legitimate as well. The Earth Charter may be viewed as the culminating product of repeated attempts since the drafting of the United Nations Charter and the Universal Declaration of Human Rights, including the long line of soft law declarations on environment and development running from the 1972 Stockholm Declaration on the Human Environment through to the 2000 Millennium Development Goals, to rewrite the global compact along more comprehensive covenantal lines (Engel, 2002). Like its precursor, Caring for the Earth, the Earth Charter affirms "respect and care for the community of life" – a time-honoured covenantal principle – as the overarching principle of moral obligation (Miller and Westra, 2002: 11).

One of the most significant contributions the Earth Charter can make at this juncture in world history is to serve as a framework and catalyst for continuing the dialogue on global ethics and moving the international covenant-making process forward.

Reading the Earth Charter with soil and soil responsibilities in mind, we can see that it is not a complete or fully adequate document. Soil is mentioned only three times, and those in passing. Nonetheless, the Charter is an invaluable resource for understanding the basic moral approach we need to take to soil and the moral guidelines we need to follow for promoting better land care throughout the world, while an explicit elaboration of soil ethics can substantially improve the Charter's conceptual foundations and practical effectiveness. On this basis, we may greet the prospects of a dialogue between the

[1] Available at: www.earthcharter.org.

Earth Charter and a revised World Soil Charter and World Soils Policy, or a new Global Charter for Land Care and a "new, binding, international instrument concerning the protection and sustainable use of soils", as suggested in the Programme for Action that emerged from the International Forum (Bigas et al., 2009: 192), as a positive step towards advancing both the conservation of soil and the Earth covenant (Hannam and Boer, 2002).

2. The Contributions of Soil Ethics to the New Earth Covenant

2.1. Eco-justice

The most significant development that may be traced through the long line of international declarations that paved the way to the Earth Charter is the recognition, beginning at Stockholm, that the most urgent environmental issues of the world are inseparable from the most urgent social issues. Growing awareness of these relationships fuelled the discussion of 'sustainable development' in the 1980s and 'just and sustainable communities' in the 1990s, and has subsequently expanded to include security and peace. The Earth Charter expresses this evolution in global ethics in its explicit adoption of what has come to be called an 'eco-justice' ethic, an integrative moral approach in which ecological and social (including economic, political and cultural) well-being are considered both dependent and independent variables. The 71 principles of the Earth Charter spell out our obligations for "Ecological Integrity", "Social and Economic Justice" and "Democracy, Nonviolence and Peace", attending not only to the specific obligations we have for each of these basic moral concerns, but also spelling out the relationships between them. Principle 7, for example, expresses the imperative of integrating a wide range of interdependent ecological and social values: "Adopt patterns of production, consumption and reproduction that safeguard Earth's regenerative capacities, human rights and community well-being" (Miller and Westra, 2002: 12).

In past years, out of a laudable zeal to bring attention to the devastating degradation of soils across the world, advocates of soil conservation often isolated the values of land care from other great questions of global ethics such as poverty, human rights and military conflict. There were tendencies to interpret soil as primarily a resource commodity and to restrict moral concern for soil to its role in agriculture, thus neglecting the many different and critical roles soils play in the evolution and ecology of the planet.

The 2007 International Forum on Soils, Society & Global Change held in Selfoss took major strides towards breaking through this single-minded vision. The presentations forthrightly addressed the intimate connections of soil health to other matters of global concern such as climate change, poverty, biodiversity loss and unrestrained economic and population growth. It made clear why we cannot hope for significant change in soil conservation values and practices without also addressing these other issues and putting into practice principles of social and economic justice, human rights, democratic participation, non-violence and international law, nor can we hope to make significant headway on these global social issues without paying more attention to the functions soil performs in sustaining the ecosphere and human civilization. The Forum thus not only lifted up the crucial importance of soil for the future of humankind and the planet, but also showed how soil demonstrates the validity of the strong eco-justice approach of the emerging Earth covenant.

2.2. Ecological integrity

A distinguishing feature of the Earth Charter is the prominent place it gives to ecological integrity as an ethical as well as scientific principle. The second of the four main sections of the Charter is entitled "Ecological Integrity." Principle 5 states: "Protect and restore the integrity of Earth's ecological systems, with special concern for biological diversity and the natural processes that sustain life" (Miller and Westra, 2002: 11-12).

Brendan Mackey, Professor at Australian National University and the member of the Earth Charter drafting committee most responsible for its emphasis on ecological integrity, writes that "ecological integrity can be understood in terms of the capacity of Earth's ecosystems to continue flourishing so that the environmental services are maintained upon which the well-being of humans and all life depend" (Mackey, 2004: 79). A major contribution that soil ethics can make to the Earth covenant is to emphasize the fact that soil integrity is both a critical component of ecological integrity and its *sine qua non* – that without which there will not be ecological integrity.

An influential figure in the field of soil conservation and environmental ethics who can help make that argument is Aldo Leopold, American forester and wildlife ecologist, 1887-1948, whose book, *A Sand County Almanac*, recounts his experiences restoring a tract of land on the Wisconsin River and climaxes in a proposal for a 'land ethic' that makes ecological integrity a first principle of environmental ethics.

The primary motivation of Leopold's career was what he called "the oldest task in human history: to live on a piece of land without spoiling it" (Leopold, 1991: 254). He came to that understanding as a result of his first-hand experiences of soil erosion and degradation, first on rangelands in the American southwest, and then in the agricultural areas of the Midwest. In 1921 he wrote:

"With enough time and money, a neglected farm can be put back on its feet – if the soil is still there. With enough patience and scientific knowledge, an overgrazed range can be restored – if the soil is still there. By expensive replanting and a generation or two of waiting, a ruined forest can again be made productive – if the soil is still there. With infinitely expensive works, a ruined watershed may again fill our ditches or turn our mills – if the soil is still there. But if the soil is gone, the loss is absolute and irrevocable" (Johnson, 1999:76).

Three years later he wrote: "Soil is the fundamental resource, and its loss the most serious of all losses" (Johnson, 1999: 80).

Leopold used 'land' to describe soil, water, plants, animals and people collectively, and he often spoke of land as a 'community'. He preferred land over terms such as ecosystem because it communicated to the ordinary citizen our primary dependence on fertile soil; his choice of community was influenced by the new field of ecology, often defined as the 'science of communities'. But Leopold was also well versed in the writings of the Hebrew prophets. His ideas of 'land community' and 'land ethic' may be interpreted as contemporary science-based translations of their understanding of an aboriginal covenant between God, people and the Earth. Leopold's proposal for a land ethic may be set forth in the form of a syllogism (Callicott, 1999: 311, 313):

1) "All ethics rest upon a single premise: that the individual is a member of a community of interdependent parts. [It is] a limitation on freedom of action in the struggle for existence – [a way of evolving] modes of cooperation."
2) We are members of the land community.
3) Therefore, we need to exercise the same constraints on our relations to the other members of the land community – soils, waters, plants and animals – as we do in our relations to people.
4) Thus, the land ethic: "A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise."

From which we may extrapolate: "A thing is right when it tends to preserve the integrity, stability and beauty of the soil community. It is wrong when it tends otherwise".

By 'stability', Leopold meant the capacity of the land to cycle nutrients efficiently and continuously because its biotic pyramid was intact and its food circuits were open; by 'integrity', he meant that the land possessed all the parts needed to maintain its stability and their successful coordination through competition/cooperation; by 'beauty' he meant the "pleasing appearance to the eye, ear, and soul" of land that possesses stability and integrity (Newton, 2006: 347). Since the mid-20th century, new scientific notions of nature as dynamic, ever-changing, even chaotic, and species and individual interactions as selfish, rather than symbiotic, have challenged earlier ecological notions of nature as composed of 'integrated communities' in dynamic equilibrium with a diverse array of species in positive interactions with one another. In light of these developments, environmental ethicists such as Baird Callicott have sought to dynamize the concept of 'land ethic' and incorporate the crucial norms of scale in evaluating anthropogenic changes in nature (Callicott, 2002). Regardless, it is unlikely that ecological integrity as such, defined as "the capacity of Earth's ecosystems to continue flourishing so that the environmental services are maintained upon which the well-being of humans and all life depend" (Mackey, 2004: 79) and its crucial component, soil integrity, will ever be dislodged as a primary focus of our covenantal responsibilities to the Earth.

2.3. Stewardship

Global ethics must also address the covenantal dimensions of the Earth community's passage through time and the responsibilities we bear, as individuals and societies, for passing on a healthy biosphere, including the responsibilities we bear to past, present and future generations of humans for the sustainable use and just distribution of the resources of nature, all of which may be summed up in the ethical imperative to serve the common good.

To assume an inclusive, long-term responsibility for the goods of nature and the resources humans make of nature is often identified with the idea of 'stewardship'. It is surprising that the term 'stewardship' does not appear in the Earth Charter[2]. But the principle of stewardship is included in its Preamble: "The protection of Earth's vitality, diversity and beauty is a sacred trust", and in Principle 4: "Secure Earth's bounty and beauty for present and future generations" (Miller and Westra, 2002: 9,11).

Stewardship was a concept with great motivational power at the beginning of the conservation movement in the early twentieth century, and it has re-emerged in recent years in the ethics of sustainable development. But its origins lie in the common property arrangements of hunter-gatherer and pre-modern agrarian and nomadic societies. In these societies, individual family units agreed to share land as a common property arrangement that gave each family the right of use but not ownership (Northcott, 2006). This was the social context in which the biblical understanding of stewardship arose – evident, for example, in the story of Joseph who was entrusted with the position of guardian (custodian, manager, overseer, caretaker, trustee) of the land of Egypt, and who by careful oversight and foresight so conserved the produce of the land that famine was avoided and the common good secured. Patrick Dobel writes: "The stewardship imperative assumes that the moral and ecological constraints are respected, and it adds the obligation to distribute the benefits justly. The steward must 'give them their portion of the food at the proper time'" (Dobel, 1998: 29).

The 'stewardship ethic' therefore has three elements: (i) long-term responsible care for the common goods of nature; (ii) sustainable ecological and economic use of these goods; and (iii) just sharing of these goods – and these responsibilities – among the population at large.

It is difficult to imagine a more powerful example of what stewardship in this original moral sense means than stewardship of soil. It is the common property of the human and natural community; we must use it sustainably; its care and its benefits should be shared by all members of the human community.

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[2]Two reasons are offered for this omission. One is that no word or its equivalent could be found in some important world cultures – Russia is an example. A second is that for indigenous peoples the word implies a separation from nature or a paternalistic relationship; evidence, unfortunately, for the ways in which the term has taken on meanings alien to its origin.

Prevailing land use practices substitute short-term gains for wise stewardship. The addition of synthetic fertilizers may, for a time, produce yields equal to or even better than soils whose structure, moisture-retention and nutrient levels have been enriched by crop rotation and manure. Monopoly of land ownership and control can increase efficiency and help maximize soil productivity in the short run. But stewardship for the long term requires soils whose inherent fertility has been retained by sound land use practices, equitable land tenure and fair resource distribution.

In 1938, Walter Loudermilk, a close colleague of Aldo Leopold, published the first extensive documentation of the consequences of soil exhaustion in the fall of civilizations. Soon afterward he composed what Moses might have given as the Eleventh Commandment, had he foreseen such consequences (italics added):

"Thou shalt inherit the Holy Earth as a *faithful steward*, conserving its resources and productivity from generation to generation. Thou shalt safeguard thy fields from soil erosion, thy living waters from drying up, thy forests from desolation, and protect thy hills from overgrazing by thy herds, that thy descendants may have abundance forever. If any shall fail in this stewardship of the land thy fruitful fields shall become sterile stony ground and wasting gullies, and thy descendants shall decrease and live in poverty or perish from off the face of the earth" (Loudermilk, 1975: 28).

2.4. The Precautionary Principle

Scientific uncertainty has frequently been used as a reason to avoid taking action to protect the environment. The Precautionary Principle recognizes that lack of certainty regarding the threat of environmental harm is to be expected, and that this should not be an excuse for not taking action; rather, it is only more reason for positive moral approaches to the environment such as preserving ecological integrity and stewardship. The Earth Charter states the Precautionary Principle in those terms (Miller and Westra, 2002: 12):

a) "Prevent harm as the best method of environmental protection and, when knowledge is limited, apply a precautionary approach.
b) Take action to avoid the possibility of serious or irreversible environmental harm even when scientific knowledge is incomplete or inconclusive.
c) Place the burden of proof on those who argue that a proposed activity will not cause significant harm and make the responsible parties liable for environmental harm.
d) Ensure that decision-making addresses the cumulative, long-term, indirect, long-distance and global consequences of human activities.
e) Prevent pollution of any part of the environment and allow no build-up of radioactive, toxic, or other hazardous substances.
f) Avoid military activities damaging to the environment."

At its core, the Precautionary Principle is an acknowledgement of the limits of our knowledge of the natural world and an admonition to be wary of all forms of technological and economic boosterism that promise quick fixes to environmental problems. Accepting our finitude and ignorance requires a moral stance of humility and prudence, one that must be explicitly woven into the covenant we make with one another and the Earth. The 2007 revised International Union for Conservation of Nature (IUCN) *Guidelines for Applying the Precautionary Principle to Biodiversity Conservation and Natural Resource Management* makes this point clear: "Implementing the Precautionary principle entails…humility and restraint, acknowledging human fallibility in the quest for certainty, the limits of science, and the tendency to over-reach in the quest for human security and well-being" (IUCN, 2007).

Since our knowledge of soil is limited and our understanding of how effectively to conserve and restore it under contemporary ecological and social conditions even more so, the Precautionary Principle must be an important part of soil ethics. Soil science and conservation both confirm and benefit from the Earth Charter's strong endorsement of the Precautionary Principle, and the covenantal virtues of humility, restraint and prudence that inform it.

2.5. Common but differentiated responsibilities

One indication that the nations of the world are groping toward a covenantal – and therefore federalist – understanding of global governance is the fact that the principle of 'common but differentiated responsibilities' has become an increasingly prominent component of international law (Stone, 2004). Although the Earth Charter does not explicitly reference the principle of 'common but differentiated responsibilities', it does affirm a federal model of 'partnership' for global governance in its declaration: "We are at once citizens of different nations and of one world in which the local and global are linked"; and its admonition that with "increased freedom, knowledge, and power comes increased responsibility to promote the common good" (Miller and Westra, 2002: 10, 11).

Informed by formal principles of global equity and justice, international agreements such as the 1992 United Nations Framework Convention on Climate Change (UNFCCC) have focused on the implications of the principle for economic, political, and technological differences, and these are undoubtedly important considerations for understanding the respective obligations of different nations to address global soil issues; but the principle can also illumine another aspect of our understanding of the interdependence of soil, society and global change. It can help us to grasp the importance of the diverse ways in which cultural attitudes and belief systems impact our relationships to the land. How we understand and discharge our responsibilities for soil are rooted in the distinct bio-geo-cultural narratives of our several societies. As indicated in the Programme for Action of this Forum (Bigas et al., 2009: 192) "[e]xperiences of soil stewardship and restoration efforts in communities around the world are diverse and location-specific." It follows that our differing bio-geo-cultural interpretations of the meaning and significance of soil need to be brought into dialogue with one another and their respective strengths and limitations identified if we are to build a rich covenantal culture of international land care.

Aldo Leopold vigorously pursued a scientific and ethical critique of what he considered to be the biblically-inspired narrative of ‘Abrahamic land conquest’. It was in counterpoint to this narrative that he generated his alternative narrative of the ‘land ethic’ and sought in *A Sand County Almanac* to communicate the new vision to his fellow citizens.

“We are the landscape,” Iceland’s former president, Vigdís Finnbogadóttir, declared during the International Forum. The power of the Iceland bio-geo-cultural narrative was apparent in the wood carvings that graced the walls of the Soil Conservation Service headquarters at Gunnarsholt, telling the story of the original promise of the Island Commonwealth 930-1262, the erosion of its land, its prosperity, and its democracy in the subsequent centuries, and the rebirth of the Republic and the efforts to restore the land in the twentieth century. It was also apparent in the narrative of the Soil Conservation Service itself, which for a century has worked to realize Hannes Hafstein’s vision that a time will come when the ‘land’s wounds are healed’. The Soil Conservation Service of Iceland modeled the principle of ‘common but differentiated responsibilities’ when it decided to convene an International Forum where it could contribute the inspiration – and the lessons – of its own history to others working on behalf of soil conservation in many different cultural and environmental contexts and to the common task of finding a way forward for the world as a whole.

2.6. Earth spirituality

Some sympathetic yet critical voices, such as environmental philosopher Strachan Donnelley, have raised the question of whether current conceptions of the Earth covenant, as reflected in the text of the Earth Charter, have “taken the Earth seriously enough or bound humanity sufficiently to the Earth’s well-being” (Donnelley, 2004: 96).

What Donnelley and others are saying is that to take the Earth’s evolution seriously requires accepting the realities of deep time, the dynamics of evolutionary change, basic continuity rather than radical disjunction between ‘living’ and ‘non-living’, a geocentric rather than an anthropocentric worldview, the need for protecting a majority of the Earth’s surface from human interference if evolution is to continue unimpaired, and a profound personal solidarity and intimacy with the natural world. They discern reluctance in current discussions of global ethics to forthrightly acknowledge that we are not the reference point of Earth’s evolution, but mortal creatures who like all creatures are born and die of Earthly processes, are absolutely dependent upon them for our sustenance, and completely bound with them in a common destiny.

Soil is our most direct link to the evolutionary origins of life in the waters of the planet, and the greatest repository we have of the early history of Earth’s evolution. We – and all other forms of terrestrial life – are absolutely dependent upon it. It may well be that a reluctance to appreciate the importance of soil in our lives is due to a reluctance to accept the full spiritual implications of our participation in this reality. If so, then a contribution that soil ethics can make to the Earth covenant is to bring this reality to our consciousness, and encourage the emergence of an evolutionary spirituality that can celebrate, rather than deplore, our Earthly identity.

Many of the great religious traditions of the world have acknowledged this reality. We speak in theology of ultimate reality as the ‘ground of being’. ‘Human’, ‘humility’, and ‘humus’ come from the same ancient Indo-European root meaning ‘soil’. ‘Adamah’ means soil in Hebrew, and Adam means the ‘son of soil, formed from the dust of the Earth’; Eve is ‘the mother of all living’ and therefore Adam and Eve literally mean ‘soil and life’. The Indian Upanishads bear similar understandings. Moreover, as the widely-read agrarian essayist Wendell Berry reminds us, “soil is the place where death becomes life again” (Johnson, 1999:74).

Soil makes clear the meaning of the covenant of being, that all creatures are fellow voyagers in the great ecological and evolutionary odyssey of ‘dust unto dust’. Soil reveals some of the most important conditions laid down by the Creativity in which we participate and upon which all life depends.

Conclusion

A ‘new covenant with Earth’ can be nothing less than a transformation of our individual and communal commitments so that they are in keeping with truly universal principles of global justice, peace and sustainability. The post-World War II history of international accords leading to the Earth Charter and the Millennium Development Goals indicates that such a process has begun. But it will take much additional ethical reflection, opportunity for trans-cultural dialogue, and determined efforts by conscience constituencies and political and business leaders across the world if it is to be carried forward. Making a true covenant with Earth ultimately requires the participation of every person and society on the planet, and the critical reform of every ecological, economic, social and spiritual relationship of human life.

Increased awareness of our ethical responsibilities to and for the soils of the planet is an essential component in moving this process forward. Not only is responsibility for soil health by every person and community a biophysical precondition of our future existence on the planet, and therefore any opportunity we may have to exercise every other form of covenantal responsibility, but by understanding the special character of our ethical responsibilities for soil we are able to better understand the meaning of all our obligations to one another and to the rest of nature. Soil ethics become a paradigmatic case of what is universally required of us. It is no coincidence that in the English language we employ the same word, ‘earth’, as a name both for soil and for the planet.

We have examined six ways in which soil ethics lifts into clearer view both our special ethical responsibilities for soil health and our general covenantal responsibilities for sustaining the community of life. We have argued that: (1) successful soil policy requires that ecological and social imperatives be addressed together, as a matter of eco-justice; (2) the need for soil integrity demonstrates why ecological integrity must be the first principle of our commitment to sustainability; (3) soil 'stewardship' is grounded in intra- and inter-generational covenants; (4) the need for precaution in the ways we treat soil reveals the limits of our scientific and practical understanding of how to conserve all the planet's resources; (5) a 'common but differentiated' approach to our cultural as well as economic and technological capacities for land care is a foundational principle for global ethics; and (6) our destiny as humans and humus reveals the evolutionary and spiritual solidarity we experience with all creatures on Earth.

We have also suggested several ways in which the Earth Charter's Principles may be drawn upon to better understand the content of soil ethics, and conversely, how attention to soil ethics has the potential to enhance the conceptual foundations and practical effectiveness of the Earth Charter. Not least important, in respect to the latter, is the need to address the omission of soil as a major subject in its own right in the text of the Earth Charter and to explicitly recognize our responsibilities for soil health in the ongoing global ethics dialogue.

A new covenant with soil is essential to making a new covenant with Earth. It is also a test of whether we will be able to succeed in answering the great calling of our age.

References

Bigas, H., G. I. Gudbrandsson, L. Montanarella and A. Arnalds (eds.), 2009. "Programme for Action" in *Soils, Society & Global Change: Proceedings of the International Forum Celebrating the Centenary of Conservation and Restoration of Soil and Vegetation in Iceland, 31 August – 4 September 2007, Selfoss, Iceland*. European Commission – Joint Research Centre, Italy, p. 192.

Callicott, J.B., 1999. "Into Terra Incognita" in Meine, K. and R.L. Knight (eds.), *The Essential Aldo Leopold: Quotations and Commentaries*. The University of Wisconsin Press, Madison, Wisconsin, USA, pp. 296-313.

Callicott, J.B., 2002. "From the Balance of Nature to the Flux of Nature: The Land Ethic in a Time of Change" in Knight, R.L. and S. Reidel (eds), *Aldo Leopold and the Ecological Conscience*. Oxford University Press, New York, USA, pp. 90-105.

Dobel, P., 1998. "The Judeo-Christian Stewardship Attitude to Nature" in Pojman, L.J. (ed.), *Environmental Ethics: Readings in Theory and Application*. Wadsworth Publishing, Belmont, Mass., USA, pp. 26-29.

Donnelley, S., 2004. "Chartering the Earth for Life's Odyssey" in *Worldviews: Environment Culture Religion*, 8 (1): 93-100.

Engel, J.R., 2004. "A Covenant Model of Global Ethics" in *Worldviews: Environment Culture Religion*, 8 (1): 29-46.

Engel, J.R., 2002. "The Earth Charter as a New Covenant for Democracy" in Miller, P. and L. Westra, (eds.), *Just Ecological Integrity: the Ethics of Maintaining Planetary Life*. Lanham, Maryland: Rowman and Littlefield, USA, pp. 37-52.

Hannam, I. and B. Boer, 2002. *Legal and Institutional Frameworks for Sustainable Soils: A Preliminary Report*. IUCN, Gland, Switzerland and Cambridge, UK.

IUCN, 2007. *Guidelines for Applying the Precautionary Principle to Biodiversity Conservation and Natural Resource Management*. Available at: http://cmsdata.iucn.org/downloads/ln250507_ppguidelines.pdf.

Johnson, P.W., 1999. "Traveling in the Right Direction" in Meine, K. and R.L. Knight (eds.), *The Essential Aldo Leopold: Quotations and Commentaries*. The University of Wisconsin Press, Madison, Wisconsin, USA, pp. 76-77, 80.

Leopold, A., 1991. The River of the Mother of God and Other Essays, Flader, S.L. and J. B. Callicott (eds.). The University of Wisconsin Press, Madison, Wisconsin, USA.

Loudermilk, W.C., 1975. *Conquest of the Land through 7,000 Years*, rev. ed. US Dept. of Agriculture Information Bulletin, no. 99, 1938. Washington, D.C. USA.

Mackey, B.G., 2004. "The Earth Charter and Ecological Integrity – Some Policy Implications" in *Worldviews: Environment Culture Religion*, 8 (1): 72-86.

Miller, P. and L. Westra (eds.), 2002. *Just Ecological Integrity: The Ethics of Maintaining Planetary Life*. Lanham, Maryland: Rowman and Littlefield, USA.

Newton, J.L., 2006. *Aldo Leopold's Odyssey*. Island Press, Washington, USA.

Northcott, M., 2006. "Soil, Stewardship and Spirit in the Era of Chemical Agriculture" in R.J. Berry (ed.), *Environmental Stewardship: Critical Perspectives—Past and Present*. T & T Clark, London, pp. 213-219.

Stone, C.D., 2004. "Common but Differentiated Responsibilities" in *International Law. American Journal of International Law*, 98, pp. 276-301.

Engaging Stakeholders in Integrated Natural Resource Management: Approaches and Guidelines from Landcare

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Introduction

The world is becoming more integrated, and "integration" surfaces as the most important concept in modern society. It is a concept that emerges strongly in the field of natural resource management (NRM) because of the complexity of the systems involved. Although resource degradation is a physical process, its underlying causes are deeply rooted in complex socio-cultural, economic and political contexts. Integrated approaches require greater involvement of different types of stakeholders, but the obstacles to successful stakeholder engagement remain, despite the growing recognition of its benefits to NRM. Stakeholder engagement may not be inherently difficult – the difficulties are externally imposed by the way the rules of engagement are set. Government decentralization is a policy trend that is favourable for stakeholder engagement at the local level, providing ample scope for integration, negotiation and collaboration.

This paper presents examples of approaches and guidelines for stakeholder engagement in Landcare – a community-based approach that applies innovative solutions to NRM challenges, fostering greater stakeholder engagement by linking farmers with the broader community and helping them influence NRM policy. As an approach, Landcare focuses on empowering local people to willingly take action on local problems and integrating actions to address broader issues with a wider applicability across geographic locations with differing or similar biophysical, socio-cultural and political contexts. It serves as a platform for all walks of life to fully express their land ethos in a concerted way. Landcare is thus a "proof of concept", demonstrating successful stakeholder engagement in NRM.

1. Background and Context

In the field of natural resource management, 'integration' emerged as an important concept (CGIAR, 2004), owing to the numerous complex systems involved. For example, a farmer engages in crop production as part of a broad livelihood portfolio that encompass a wide variety of off-farm activities, such as the gathering of forest products, raising livestock, marketing products, etc. (CGIAR, 2004). But the farmer, in this case, is not only concerned with productivity enhancement, but also risk reduction and sustainability of crop production. Because of the variability of production inputs (e.g. soil fertility, land and labour availability, etc.) and volatility of outputs, the farmer will constantly struggle to meet his production goals, while managing the basic resources upon which production depends; all of which are affected by local conditions (from the household level) and the constantly changing economic climate. As the land is degraded, productivity declines and incomes fall, and poor farmers are often blamed for environmental degradation due to their lack of conservation ethic (Boada, 1988; Catacutan, 2007). Nelson (1996) argues that this is understandable given the lack of incentive to practice soil conservation due to the cycle of poverty and skewed patterns of economic development (Catacutan, 2007). It is said that even if resource degradation is a physical process, its underlying causes are deeply rooted in complex socio-cultural, economic and political contexts – with population pressure, changes in economic patterns imposed by global market competition, and low production, the world's rural poor are trapped in a vicious cycle of poverty (Catacutan, 2007). According to Nelson (1996), this downward spiral is hard to break without external assistance.

In seeking to address the complexity of NRM, the Consultative Group on International Agricultural Research (CGIAR) has adopted the Integrated Natural Resource Management (INRM) approach as a unifying research framework. Researchers defined INRM as a conscious process of incorporating multiple aspects of natural resource use into a system of sustainable management to meet the explicit goals of resource users, managers and other stakeholders (e.g., production, profitability, risk reduction and sustainability goals)[1]. This means integrating across disciplines, across scales, across stakeholders, and across components (Lal, 2001). This implies major changes in the culture and organization of research (Ashby, 2001), and in this case, not only that INRM is built into a social learning process, but it also requires institutions to evolve as learning organizations, employing institutional flexibility and promoting conditions that are favourable to complex learning and integration of scientists with other stakeholders (CGIAR, 2004).

Natural resources are influenced by the day-to-day management decisions of large numbers of different types of actors or stakeholders at various scales (Van Noordwijk, 2001); INRM should therefore be stakeholder-centred. These stakeholders (e.g., small and large holder farmers, policy-makers, managers, administrators, businesses, scientists, communities, and other economic and social sectors) often have contrasting objectives and activities, based on their specific circumstances, and influenced by a multitude of exogenous factors. In the context of NRM, 'integration' will be based on multi-stakeholder situations and multiple objectives, which are hinged on dynamic systems, and ingrained in complex social arenas. Stakeholders, at different levels and stages, are crucial to the success of NRM interventions. However, the processes involved in engaging stakeholders can be also complex and time consuming. A common critique about stakeholder engagement is the high inputs or costs involved in building relationships and partnerships. Such inputs are not limited to financial or material resources, but also include social or personal relationships. The latter are usually unaccounted for, in conventional project management, and are even hardly recognized as inputs or costs by stakeholders (Catacutan et al., 2001), even though personalities and social relations are essential ingredients in any successful stakeholder engagement. The outcomes of stakeholder engagement are expected to be significant, including community empowerment, ownership

[1]Defined by scientists convened by CGIAR at a meeting in Penang, Malaysia in August, 2000.

and sustainability. In the process of engaging stakeholders, adaptive capacity is developed, because people are given the time to strengthen networks, knowledge, resources and the willingness to find solutions (Conde and Lonsdale, 2006).

2. The Landcare Approach

Landcare movements began emerging in the mid-1990s as an approach for mobilizing collective action by local farming and ranching communities concerned about land degradation and NRM challenges (Bumacas et al., 2007). The movement is based on the Landcare approach – a community-based approach that employs innovative solutions to NRM challenges, linking farmers with the broader community and helping them to influence NRM policy. The approach centers on the formation of community land care groups, supported to varying degrees through partnerships with government and non-government agencies (Cramb and Culasero, 2003; Catacutan, 2007; Bumacas et al., 2007). Community land care groups significantly benefit from the concerted support of local and national governments and other non-governmental actors. Groups with a common agenda work together to determine how problems can be solved and mobilize resources to solve them based on the principles of volunteerism and genuine participation, responding to local demand and building partnerships and support from the local level (Bumacas et al., 2007). Groups engage in varying activities, including total farm care, catchment care, vegetation management, coastal management and property planning. Landcare also builds necessary partnerships between farmers, catchment, regional approaches, and government policy to deliver broader landscape change, employing facilitators and coordinators to provide an interface between government agencies and land care groups (Bumacas et al., 2007).

Beginning in the mid-1980s, the growth of Australia's Landcare movement has been explosive, with over 4,000 Landcare groups formed. Today, thousands of farmers are organized into land care associations and institutions by some 17 countries or multilateral organizations in the Pacific, Africa, America, Europe and the UK, and South-East Asia, who are either independently implementing Landcare programmes, or receiving limited support to initiate them. The genesis of Landcare in these countries varied, and though Landcare has developed through different pathways, the problems that community land care groups are trying to address are similar, adhering to the same principles, which is the enrichment of human and social capital to mobilise local action for reversing land degradation issues and improving rural livelihoods, with emphasis on local demand, volunteerism, genuine participation, partnerships, and use of outside resources. Thus, regardless of differences in circumstances, the driving principles for mobilising local communities to achieve Landcare outcomes are quite common. The essential requirements to facilitate this process are also common, that is, a good balance between community efforts, government partnerships, and support from non-government agencies in the form of technical or institutional innovations, advocacy and funding. The genesis of these efforts and the pathways these efforts might take will vary from one situation to another, but the philosophy behind these efforts is fundamentally shared. Ultimately, in a world with many common problems and an increased emphasis on local governance, the Landcare philosophy might help to mobilise local actions for greater NRM benefits with specific variations only in the implementation strategies to suit the varying respective local conditions (Catacutan, 2007).

Evidence suggest that Landcare has significantly contributed to improving NRM and livelihood outcomes in areas where it is active. Landcare associations around the world have developed more resilient capacities to transform farming systems to mitigate and adapt to climate change through land care practices that increase carbon sequestration. In the Philippines, Landcare has served as the coping mechanism for communities to achieve resiliency. In Uganda, Australia, New Zealand, Germany, Iceland and South Africa, Landcare associations are instrumental in massive tree planting, and are actively implementing sustainable farming practices and catchment-wide management projects. Wider relevance and applicability to different situations is a characteristic of Landcare, making it attractive to a wide range of stakeholders. In Germany, Landcare associations are able to access support for projects from the European Union's Common Agricultural Policy's (EU-CAP) agri-environment schemes[2] (Blumlein, 2009), while corporate engagement in Landcare is mastered in Australia. In Iceland, Landcare initiatives are mainstreamed in regular conservation programmes, while in Uganda, Landcare efforts centre on improving access to resources and livelihood improvement. Moreover, Landcare institutions are linked horizontally and vertically to technical service providers, including research and development institutions. In New Zealand, Landcare efforts are supported by the NZ Landcare Trust, a research-based non-governmental organisation. Similarly, the World Agroforestry Centre (ICRAF) has pioneered Landcare research in the Philippines and in the East African region, while Virginia Tech University has facilitated Landcare research and development linkages in the USA. Various Australian research agencies and universities have centred many of their research activities on Landcare. Landcare has thus demonstrated a mechanism for linking scientific knowledge with actions at the local, national and international levels.

3. Issues Involved in Stakeholder Engagement

Many of the difficulties experienced in engaging stakeholders in INRM are the result of poor policy analysis and poor programme design (Gleeson, 2006). This led to the proliferation of NRM approaches that tended to embrace reductionism, resulting in institutions specializing in production, conservation, or regulation and control. This structural constraint reduces chances for innovation, integration and stakeholder collaboration. Landcare was not exempted from these structural constraints. At the national level, issues are more complex, especially when dealing with high-ranking government officials and agencies that are locked in their organizational boundaries. An example of issues related to structural constraint is presented in Box 1.

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[2]Agri-environment scheme is a strategy integrated into EU's Common Agricultural Policy (CAP) in recognition of the vital role of the environment in pushing for agriculture and economic development.

Furthermore, the complexity of issues changes with geographic scope, types of stakeholders involved, differential interests and local contexts. In areas with deep historical conflicts, stakeholder engagement needs to start by cultivating new types of relationships. An example of issues in stakeholder engagement with deep historical conflict is presented in Box 2.

Box 1. Issues in Stakeholder Engagement with regards to Structural Constraints in the Philippines.

The Department of Environment and Natural Resources (DENR) in the Philippines is the primary agency responsible for the management of the country's natural resources. It controls decision-making, funding and project management but, with limited funds to support forest development projects, DENR's work is more regulatory than developmental.

On the other hand, the Department of Agriculture (DA) is the principal government agency responsible for the promotion of agricultural development. It provides the policy framework, helps direct public investments, conducts research, and in partnership with local governments provides support services necessary to make agriculture a profitable enterprise and helps to spread the benefits of development to the rural poor. Interfacing with these agencies is the National Economic Development Authority (NEDA), the central planning body which directs or influences agency programs, and decides on projects funded by foreign donors.

Engaging stakeholders at the level of these central agencies was daunting, due to differences in organizational cultures and priorities. DENR and DA have very distinct roles and responsibilities. The former is in charge of all public lands, while the latter is tasked on private lands, and their efforts have been disconnected. Both agencies understood the broad aspects of Landcare, encompassing their agency mandates; however, "integration" seemed difficult because of "turf" issues – in some cases, Landcare initiatives are in state forest lands, but are also active in many private lands. In some instances, the NEDA gives preferential treatment to certain agencies, causing more confusion when it comes to deciding on the most appropriate stakeholder. Competition between agencies and structural issues make it very difficult to determine the most legitimate stakeholder with which to engage.

Box 2. Issues in stakeholder engagement: the case of Mt. Elgon National Park and the Benet in Uganda.

The Benet, traditionally hunters and gatherers, have resided in the forests and Moorands of Mt. Elgon National Park in eastern Uganda. Shifting conservation policies, from informal acceptance of Benet residence and use of protected area resources under British rule to forced exclusion from the park, have created tensions between the people and protected area officials.

In addition to official fines, abuses committed by local level protected area officials have exacerbated the conflict. Negative conceptions of each party have prevailed: the Uganda Wildlife Authority (UWA) officials treated the Benets as encroachers and the Benet considered the UWA officials as having an interest only in trees and animals. The history of Benet marginalization from their traditional resource base led them to pursue a legal resolution to resolve the conflict at the national level. A court case was passed to seek reinstatement of Benet land rights. A first gesture of reconciliation was initiated by the Kapchorwa Landcare District Chapter (KADLACC) and its supporting institution, the African Highlands Initiative (AHI).

Identifying the stakeholder with which to work closely at the initial stage was problematic – the issue was so sensitive that any wrong move can easily spark a fire between the two parties. KADLACC officials started by identifying allies and lobbying with both parties. Through constant communication and negotiation, the impasse was unlocked by focusing on "interests" rather than "positions" within Mt. Elgon. Later, both parties agreed on a certain "bottom line" that is, "biodiversity conservation" in Mt. Elgon. The lesson learned is that conflict among stakeholders can be reduced if each party concedes something to the other, in the spirit of reconciliation and the collective good. In this case, KADLACC has served as the honest broker and negotiator. Finally, KADLACC learned that effective stakeholder engagement can be done by breaking communication barriers and by making "common interest" more explicit between parties, rather than what one holds in society.

Another issue raised in stakeholder engagement is in the way such engagement is being sought. According to Gleeson (2006), difficulties are created by the external setting of directions, indicators and targets, by not having common languages and processes across the landscape, by differing timeframes for engagement, and by ineffective and inefficient processes. Stakeholder engagement also presents a challenge to established hierarchical structures. All these can possibly be removed with proper stakeholder analysis and mapping. This is a common approach used by many Landcare practitioners to determine significant relationships between stakeholders and to examine opportunities and constraints of stakeholders.

4. Approaches to Stakeholder Engagement

There are a great number of approaches, tools and techniques to stakeholder engagement, and combinations of these are usually applied to suit to a particular situation (Conde and Lonsdale, 2006). The choice of these depends on the nature of engagement, the purpose, and the resources available to the stakeholders involved.

In Australia, home-grown ramifications of stakeholder engagement in NRM abound, including the "property planning" approach to the recent "regionalization" scheme. Amongst the many approaches employed by Australian Landcare, the Australian Landcare Management System (ALMS) has been widely and effectively used to engage and support landholders in environmental management (Gleeson et al., 2000; Gleeson, 2006). ALMS is an environmental management support system which builds on the aspirations and capabilities of individual landholders (Gleeson, 2006). The features of ALMS are presented in Box 3.

Box 3. Features of the Australian Landcare Management System (ALMS) that Promote Stakeholder Engagement (source: Gleeson, 2006).

The features of the Australian Landcare Management System (ALMS) that promote stakeholder engagement include:

- Doing rather than Talking: ALMS begins with the aspirations and capabilities of landholders, either individually or in groups. The engagement of landholders in ALMS is through a structured process of planning, doing and reviewing. Hence landholder engagement is not reliant on consultative processes with uncertain outcomes.
- Holistic rather than Reductionist: ALMS applies across the whole farm in ways connected to the broader landscape. ALMS covers all the components of ecosystems and the impacts of all activities.
- Enabling Recognition: From the outset, ALMS decided not to take the 'low road to nowhere', but rather to design a system that will deliver improved environmental management and that can be audited for local, regional, national or international recognition. To do otherwise is to potentially mislead landholders in relation to the recognition they might receive for their environmental management activities. As membership categories differ primarily only in respect to auditing landholders, working within groups allows them to choose the category of ALMS membership that best suits their individual requirements.
- Enabling Beloving: Responsibility for the development and implementation of ALMS rests with the Board of ALMS Ltd., a not-for-profit organisation established by landholders to support and provide recognition for landholders improving their environmental management. Hence, ALMS can be seen as a sort of 'tribe', and as the 'tribe' grows, so too will the mutual support which members receive from other members.
- Providing Support: ALMS trainers, coordinators and auditors support ALMS members through their portfolio of tools and processes to assist landholders develop, implement and have their ALMS action plans audited.

In the USA, the push by the current (2004-2008) US administration for "cooperative conservation" permitted Landcare to be relevant in long-established conservation institutions, and for Landcare to take on a variety of forms and functions in specific locations and situations (Robertson et al., 2009). To further engage a wide range of stakeholders, two concepts were incorporated into Landcare, namely "working landscapes" and "Triple Bottom Line" (Robertson et al., 2009). The former is a strategy for sustaining lifestyles and economies as well as landscapes; the latter has been used by management and NGO circles to push that business success should be measured not just by the traditional financial bottom line, but also by its social/ethical and environmental performance. Because of this, opportunities for Landcare in the United States are many and growing, especially as partners such as the United States Department of Agriculture and the Environmental Protection Agency along with the National Associations of Conservation Districts, Regional Councils, and RC&D Councils, and numerous corporate partners continue to step forward to play a supporting role (Robertson et al., 2000). Furthermore, the iconic "Land Care Center", spearheaded by Virginia Tech in Roanoke, Virginia, was formed as a public-private partnership initiative to serve as a platform for stakeholder engagement with the primary purpose of facilitating the formation and development of local community land care groups, regional networks and innovative land care industries by providing information and decision support to land care practitioners and serving as a conduit to existing land care organizations and programmes throughout the state and beyond (Robertson et al., 2009).

In Germany, Landcare projects are funded by various stakeholders, including individual farmers, local governments, state and federal governments, and the European Union agri-environment schemes. Stakeholders increased with the expansion of project activities, from planting trees or hedges and cutting grass to maintaining diverse cultivated landscapes, and later to promoting sustainable management of extensive land-use systems through some form of eco-labelling by helping farmers market their quality products, such as apple juice and lamb meat (Blumlein, 2009). The Land Care Association's (LCA) efforts to promote the marketing of lamb in local restaurants have encouraged farmers' participation in Landcare activities, showing that sheep grazing on poor-soil pastures can still be economically profitable (Blumlein, 2009). As a result, farmers have become interested in employing sustainable grazing management strategies to ensure continuous production of lamb meat. In short, the sustainable livelihood approach served as a platform for engaging stakeholders in Landcare.

In South Africa, the National Department of Agriculture initiated Landcare, emphasising livelihoods and job creation. It was thought that Landcare could directly address the livelihood issues of black-dominated poor rural communities in South Africa. It was recognized that the relevance of Landcare lies largely in addressing the twin goals of economic uplifting and environmental conservation, and in the context of poor rural communities in South Africa, the idea of environmental conservation has to be clearly linked to income generation or job creation to make it more responsive to local needs (Bosoga et al., 2009). Stakeholder engagement was then built from community-based initiatives within provincial structures and involving strong private and civil society sectors. Today, Landcare is part of the Expanded Public Works Programme (EPWP), where Landcare projects/activities relate to infrastructure development, such as fencing, construction of dikes, dongas, and water reservoirs are being undertaken or assisted by EPWP. This strategy brings more stakeholders into the Landcare programme.

5. Guidelines for Stakeholder Engagement

In Landcare, the stakeholders are diverse, including property owners and resource users, community based organizations, government officials and politicians, NGOs and inter-state organizations, research and development institutions including academia, and the business sector, among others. These all come from different levels – from the paddock to small catchments or villages, sub-catchments, regional catchments and state and federal or national levels. Diversity in stakeholders gives rise to conflicting motivations and aspirations; if left unattended, such conflicts can border on hostility. As mentioned earlier, stakeholder analysis is a necessary step in identifying the most significant stakeholder. A number of methods exist to decide how these should be dealt with. Some guidelines for stakeholder engagement are discussed as follows:

a) Master the stakeholders. A fundamental step in engaging stakeholders in NRM is to master their nature, interests and positions. As mentioned earlier, this can be done only through stakeholder analysis and mapping. This allows for better understanding of the stakeholders in terms of their legitimacy, power and interest on the issues at hand.

b) Make use of existing structures. As far as possible, avoid re-organizing structures that already exist. Analyze the strengths, weaknesses, gaps and improvements needed within existing working structures, and introduce new structures only where necessary – innovate, rather than re-invent.

c) Allow time for trust building. Building trust and relationships do not just happen. They need to start from proper cultivation.

d) Ensure clarity of goals, costs and benefits. Work towards defining a clear set of goals and identifying the costs and benefits of the engagement. Build consensus on the terms of engagement rather than pushing on external rules – making false hopes is dangerous.

e) Transparency. Work on maintaining transparency at all times. Coming to terms with what is available and what is doable at the onset is practical and beneficial to all stakeholders. Although the sky is the limit when it comes to opportunities in engaging stakeholders, it is better to be transparent about the potential constraints so that early or mid-course actions can be easily detected.

f) Knowledge management. Be clear about what needs to be monitored, assessed/evaluated and/or documented at the onset. Stakeholder engagement is a journey of complex processes – without learning from it, is a wasteful endeavour.

Conclusion

There are so many aspects with which to identify the success of Landcare. One of the prominent outcomes of Landcare is engagement of a wide range of stakeholders, brought about by its inclusive nature, flexibility and adaptive capacity to change. Landcare provides opportunities for people to practice their land ethic without coercion, in a spirit of stewardship and volunteerism, complimented by various types of support and incentives. According to Robertson et al. (2009), Landcare creates opportunities by reorganizing exchanges of goods and services, creating a new type of service providers, and challenging institutional norms that favour short-term profitability over sustainability. For rural landowners, it provides an opportunity to nurture their land with sustainable, profitable management. For urban landowners, it provides opportunities to find, afford and practice green lawn care, create backyard wildlife habitat, and minimize energy consumption. For consumers, it provides opportunities to purchase locally-produced, sustainably-grown products. For professionals and scholars, it provides opportunities for intellectual discussions and developing management options. For public officials and politicians, it enables improvement of political and administrative governance, bringing public service closer to the people. Finally, for the business sector, it brings new ways of channelling their corporate social responsibilities. The common elements to stakeholder engagement are: emphasis on the broad relevance of Landcare; linking Landcare to wide-ranging sectoral interests; emphasis on “inclusiveness”; emphasis on home-grown methods and structures and less imposition of external ones; and, use of a step-wise approach – in size, scope, content and process. Landcare is thus a “proof of concept”, demonstrating successful stakeholder engagement in integrated NRM, serving as a platform for all walks of life to fully express their land ethos in a concerted way.

References

Ashby, J., 2001. “Integrating Research on Food and the Environment: An Exit Strategy from the Rational Fool Syndrome in Agricultural Science” in *Conservation Ecology* 5(2):20 [online]. Available at: http://www.consecol.org/vo15/iss2/art20.

Bluemlein, B., 2009. “Landcare in Germany” in Catacutan, D., C. Neely, M. Johnson, R. Youl and H. Poussard (eds.), *Landcare: Local Action-Global Progress*. World Agroforestry Centre, Landcare International, Australian Landcare International. Nairobi, Kenya.

Boada, E.L., 1988. “Incentive Policies and Forest Use in the Philippines” in Repetto, R.C. and M. Gillis (eds.), *Public Policies and the Misuse of Forest Resources*, University of Cambridge, Cambridge.

Bosoga, K. Taylor, S. Mkhize and B. Msomi, 2009. “Landcare in South Africa” in Catacutan, D., C. Neely C., M. Johnson, R. Youl and H. Poussard (eds.), *Landcare: Local Action-Global Progress*. World Agroforestry Centre, Landcare International, Australian Landcare International. Nairobi, Kenya.

Bumacas, D., D. Catacutan, G. Chibememe, O. Odigha and C. Rhoades, 2007. “Enabling Local Communities to Developing and Scaling-Up Agriculture: A Grassroots Perspective” in McNeely, J. and S. Scherr (eds.), *Farming with Nature: The Science and Practice of Eco-Agriculture*. Island Press, Washington, D.C.

Catacutan, D., A.J. James and J. Kumar Dutta, 2001. 'Hidden Costs and Benefits to Participation', in International Institute for Rural Reconstruction (ed.), *Enhancing Ownership and Sustainability: A Resource Book on Participation*, IFAD, ANGOC, IIRR, Philippines and India.

Catacutan, D.C., 2007. *Scaling Up Landcare in the Philippines: Issues, Methods and Strategies*. World Agroforestry Centre. Southeast Asia Regional Research Programme.

CGIAR, 2004. *Proceedings of a Workshop on Integrated Natural Resource Management (INRM)*. Consultative Group on International Agricultural Research, Penang, Malaysia.

Conde, C. and K. Lonsdale, 2006. *Engaging Stakeholders in the Adaptation Process*. Technical Paper 2. UNDP. Available at: http://www.undp.org/gef/05/documents/publications/apf-technical-paper02. Accessed 07/10/06.

Cramb, R.A. and Z. Culasero, 2003. “Landcare and Livelihoods: The Promotion and Adoption of Conservation Farming Systems in the Philippine Uplands” in *International Journal of Agricultural Sustainability*, vol. 1, no. 2, pp. 141-54.

Gleeson, T., 2006. *Engaging Stakeholders: It does not have to be so difficult*. The Regional Institute Ltd., www.regional.org.au (accessed 16/07/07).

Gleeson, T., P. Crawford and J. Douglas, 2000. *Guide to Australian Landcare Management.* Australian Landcare Management Systems Ltd, Brisbane, Australia.

Lal, R., 2001. “The Adaptive Decision-making Process as a Tool for INRM: Focus, Attitudes, and Approach” in *Conservation Ecology* 5(2):11 [online]. Available at: http://www.consecol.org/vol5/iss2/art11. Accessed 07/01/06.

Nelson, R., 1996. *Bio-economic analysis of hedgerow intercropping in the Philippine uplands*. PhD thesis, University of Queensland, Australia.

Robertson, D., C. Gabbard, B. Hull, J. Moles, J. Stokoe, S., J. Waldon and D. Lowe, 2009. “Landcare in America” in Catacutan, D., C. Neely, M. Johnson, R. Youl, H. Poussard (eds.), *Landcare: Local Action-Global Progress*. World Agroforestry Centre, Landcare International, Australian Landcare International. Nairobi, Kenya.

Van Noordwijk, M., 2001. *Participatory Technology Development in the Context of Integrated Natural Resources Management*. Paper presented to the “Workshop on Participatory Technology Development and Local Knowledge for Sustainable Land use in South East Asia. Chiangmai, Thailand.

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Incentives and Disincentives: A Systematic Approach

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Introduction

The purpose of this Forum is to pool knowledge from many disciplines and different parts of the world. This session is principally about identifying innovations that might materially enable the shift of society towards a more sustainable resource-consumption status. Over the last decade or so, I have been working with many collaborators to better understand the fundamentals of the regulatory, market and institutional arrangements likely to achieve this goal. Our approach aims to synthesize knowledge from various disciplines by attempting to go beneath the language barriers of individual disciplines to understand the fundamental concepts within law, economics, education and various other approaches to how they think about sustainability issues. The aim is to apply these concepts to consider the fundamentals of the effectiveness of different instruments such as regulation, voluntarism or market instruments, and to suggest ways of improving that effectiveness (Martin and Verbeek, 2006).

Thousands of websites, papers and books from around the world have been consulted in our attempt to understand the fundamental mechanisms and effectiveness issues. The perspectives on the topic are myriad, including regulatory theory, economics and market theory, process perspectives, social perspectives, ethical frameworks, and voluntarism and educational approaches. This paper principally reflects both our recent attempt to understand international best practices in the design of environmental instruments[1], and the preparatory work being done on a study on behavioural underpinnings of the operation of some of these instruments[2]. In tackling the regulatory study, our expectations at the outset were that:

1) A suite of sophisticated processes was available for the creation of natural resource management strategies and the regulations that form the basis for their implementation by government.
2) There was a coherent body of empirical data to demonstrate the received wisdom of the superiority of market instruments over regulation in achieving behavioural change towards sustainability.

Neither of these expectations was met. The meta-linkages between the choice of instrument and resource-use behaviour, or between instrument selection and outcome, are extraordinarily weak. There is a substantial amount of work done in different disciplines to refine their preferred instruments, but no integrative paradigm about resource consumption behaviour, the selection of instruments and instrument mixes, and the probability of a desired outcome. The value of an integrative paradigm is well demonstrated in the environmental sciences where using the concept of water cycle, soil systems, or other biophysical systems frameworks allows multi-point but targeted interventions, and identifies trade-offs between different forms of intervention at different parts of the system. In other fields, a simplifying heuristic can serve a similar role, allowing practitioners to deal integratively with very complex issues.

Further, and perhaps more disconcerting, there is no accepted process or structure for continuous learning and refinement, which would trigger the generation of some integrative paradigms. Indeed, the strategy formulation and regulatory processes which are well accepted are focused on economic analysis based on narrow perspectives. Cost-benefit analyses, regulatory or policy impact assessment, and risk-based evaluations are good examples (Baldwin and Cave, 1999; Hutter, 2005; Cole, 2006). Whilst these processes are a valuable regulatory discipline, eventually the application of these approaches may trigger the search for an underlying paradigm for a natural resource strategy, as the causal link between the use of these techniques and outcomes from natural resource management strategy is not demonstrated. Indeed, given the number of variables involved, which will be discussed next, it may not be possible to make any such links. Ex-ante economic modelling (Calcott and Walls, 2000; Ferraro and Simpson, 2000) typically does not take into account fundamental considerations like the interaction between one instrument and many others in place (focused on different goals), the capacity of these being managed to respond, resourcing constraints on the implementing agency, and the myriad of contextual factors which alter the responses to the instrument. Furthermore, other forms of failure such as negative impacts on social justice, or political economy issues, are typically not considered.

1. Challenges in Developing Environmental Instruments in the Pursuit of Sustainability

Many instrumental processes do achieve positive outcomes and some are enormously effective (Gunningham and Grabosky, 1998; Niemeyer, 1998; Clinch, Convery et al., 1999; Anderson, 2001; Stavins, 2001; Landell-Mills and Porras, 2002). However, many fail in that they can not be objectively shown to have achieved the (often poorly specified) aims that drove their creation. The forms that instrumental unreliability take include:

- Total or partial failure to achieve the desired goals;
- Excessive cost to government or to the community;
- Community resistance and political cost;
- Unexpected spillovers and perverse effects; and
- Counter-effects on other policy goals.

[1]Martin, P.V., R. Bartel, J. Sinden, N. Gunningham and I. Hannam, 2007. *Developing a Good Regulatory Practice Model for Environmental Regulations Impacting on Farmers*. Australian Farm Institute and Land and Water Australia.
[2]Collaboratively with a team from Penn State University and Macquarie Centre for Environmental Law. For details see http://sites.google.com/site/lawandbehaviour/.

Based on the research, it is clear that the gap between anticipated outcomes of various interventions in support of sustainability and the actual results is often substantial, and may not be narrowing. It certainly is not narrowing at a sufficient rate to believe that sustainability will be achieved, or in many cases even to believe that public resources are justifiably being used.

The major problem is that sufficiently positive outcomes are not consistently achieved at a level that one would expect if a solid understanding of what it takes to be successful existed. Such unreliability would be a cause of soul-searching and anxiety in almost any other science, but seems to be accepted in the science of sustainability. The empirical evidence suggests that unreliability exists regardless of whether the interventions are regulatory, market or other. The normal response to instrumental failure seems to be to create another instrument, often of the same type but sometimes using a radically different approach, and add this into the mix. This is typical not only of regulation, but also of market instruments. The fundamental causes of failure are not systematically explored, nor are they systematically addressed.

The key reason for this lack of reliability is failure in practice (though not in political rhetoric) to recognise that the pursuit of sustainability is not about instruments, but that it is about behavioural change. More efforts are being devoted to instrument design and creation (or modelling economic outcomes) when perhaps it is other issues that ought to be addressed. There is no basis for knowing whether public resources are being properly allocated because of a lack of a shared behavioural paradigm to underpin behavioural interventions.

Some of the sources of variation from expectations are:

- Poor instrument design in terms of the incentives/disincentives from the perspective of those being managed (Sparrow, 2000; Australian Bureau of Agricultural and Resource, 2001; Eliadis, Hill et al., 2005).
- Narrow selection of the ecological attributes or consumptive practices to be managed (notably single-attribute or single practice programmes[3]).
- Narrow selection of points and methods of intervention in the consumption system being managed[4] (Gunningham and Grabosky, 1998; External Advisory Committee on Smart, 2004).
- Institutional incapacity to implement, or to be credible, with those being managed (Dragun, 1999; Cary, Webb et al., 2001; Dovers, 2001; Hannam and Boer, 2002; Eliadis, Hill et al., 2005).
- Insufficiency of resources or capacity, either in the agencies or in the community being managed.
- Social, economic or other context variables (Brunner and Pejovich, 1985; Bromley, 1997; Baldwin and Cave, 1999; Aalders, 2002).
- The intrinsic potential for inequity with any form of use of constraint[5].
- Transaction costs (Maser and Heckathorn, 1987; Williamson, 1999; Anderson, 2001; Macher and Boerner, 2002; The Allen Consulting, 2006).
- Path dependence and innovation systems issues (Moxnes, 2000).
- Political economy issues (Brunner and Pejovich, 1985; Driessen, 2003; Eliadis, Hill et al., 2005).

As a result of the absence of a shared theory or paradigm, the fundamentals for continuous improvement, which has been so important in other complex human endeavours, is still lacking.

2. Integrative and Multi-Faceted: A New Approach for Sustainability

It is thus this main message that needs to be conveyed: if the outcomes are to change, then the approach needs to change as well. The evolution of sustainability science is needed at this point in order to begin to tackle the fundamentals of resource-use behaviour and to develop a sound science of consumptive-use behaviour change. This will require work at two levels. It requires integrative behavioural science drawing on a range of disciplines, each of which holds a piece of the puzzle. Economics can provide well-developed frameworks for instrument design and evaluation, particularly for market instruments. It also can bring transaction costs into focus. Social marketing has a well-developed approach to the segmentation of target groups and the design of communications. Regulatory theory can address both the design elements and compliance aspects, and also provide review and refinement processes. Psychology offers ways of thinking about risk and risk perception, attitude and the propensity to conserve, and can provide insights into how and why individuals may respond to different interventions in different circumstances. Sociology can provide insights into social systems and collective behaviour. Systems theory can provide some integrative approaches that span a range of perspectives. There may well be other disciplines that can contribute meaningfully to the creation of some integrative theory to support sustainability.

Along with this, a process for continuous improvement is needed, based on well-known principles of goal-setting, evaluation, review and adjustment. Continuous improvement approaches require an agreed theory or practice, and around this a well-structured process for capturing information about the outcomes of its application, review and then refinement of the core knowledge. In the case of natural resource strategies, it requires that processes are developed that do rigorously evaluate outcomes compared to expectations across a number of dimensions of performance. Merely carrying out regulatory impact assessments (Sparrow, 2000; Guerin, 2002; Argy and Johnson, 2003) on an economic basis will not be sufficient to fuel

[3]Attaching economic value and a rule set for achieving this value to one attribute of an ecosystem can typically be expected to result in deterioration of other values that are not 'marketised'. An example is the perverse effects on native forests from narrowly defined carbon markets.
[4]The idea of 'smart regulation' is focused around multi-point, multi-instrument interventions as a more reliable approach.
[5]This is most clearly seen with indigenous communities, who will often lose access rights when regulation or market pricing are introduced.

improvement in the environmental, social and governance performance of instruments. If this major endeavour is not embarked upon now, it is hard to see how the gap between expectations of interventions in support of sustainability and the highly variable ex-post reality can be narrowed, and even closed.

Perhaps this paper ought to have been titled 'Giving the Emperor a Wardrobe', reflecting the well-known Hans Christian Anderson tale. While many people admire the cut and the line of particular resource conservation strategies, the reality is that there are elegantly cut lapels, beautifully tailored cuffs, and nicely sewn pockets. What is lacking though is the integration of these into a well-fitting suit. Rather unattractive bits of naked flesh peep through if one is prepared to use one's own eyes rather than take the word of the tailors.

Below is an attempt to outline some conceptual directions that may assist in developing an approach. However, the lack of a clear conceptual framework for understanding how and why people behave in particular ways in response to different interventions is not something that will be easily solved.

3. A 'Straw Man' to Consider

The goal at this Forum is to recognise problems and challenges, and then to propose ways of solving them. The 'straw-man' that will be presented is put up for the purpose of allowing one to pull him apart and rebuild into something that is useful. It is only intended as a first step to accelerate progress; it is certainly not intended as the definitive approach.

Key Elements:

1) Closely coupling biophysical systems analysis with economic, legal and institutional analyses. There is a substantial body of physical sciences modelling of the environment. There is also a substantial amount of economic modelling. These two forms of modelling are only loosely coupled in policy formulation – it is rare that the work of economists and that of system modellers is integrated. The policy aspects, such as legal and institutional analyses, are even more rarely linked into these models. Linking all three ought to enable one to properly understand how different policy interventions will impact economically and on resources. Closing this loop will provide a more reliable basis for debating the cause and effects of policy interventions.

2) Focusing on transactions as pivots, with transaction costs being an important lens. Transaction costs in this context means not only the conventional economic costs, but also the 'taxing' of information flows and the 'taxing' of resource flows. The effect that people have on the environment, and the economics of their doing so, are mediated through transactions at different points in the resource use system. These transactions might be economic, or they might be motivated by social or individual incentives. Understanding what transactions are pivotal to the system being managed, and what 'drives' these transactions, will allow the identification of potential interventions. Transaction costs such as the effects of uncertainty, the costs of contract design, and various barriers and filters in the flows of information have a significant effect on what transactions actually do occur (compared to those that theoretically might), and for this reason need to be specifically considered in the design of possible interventions.

3) Understanding the practical and psychological considerations that have an impact on the response of the targeted people and organisations to any intervention. It is clear that individuals do not respond homogenously to the same incentives, and therefore that tightly targeted psychologically and demographically 'segmented' programmes ought to be more effective than homogenous ones. Developing behaviourally meaningful methods for segmentation, and for the design of programmes to meet targeted needs, would seem to be an element that needs to be advanced.

4) Recognising that all instruments work on the same things, but in different ways. There are only two flows (signals and resources) in a social system. Whilst different disciplines use different languages and different analytic techniques and prefer different forms of intervention, the underlying mechanisms are substantially common and amenable to integration. Thus, any unifying conceptual framework for behaviour change towards sustainability ought to address both the flow of funds and other resources, and also the flows of information that are the feedstock of decisions. It is only through these flows that, over time, decision-making structures like culture, values, and analytic techniques can be modified to be more conducive to sustainability.

5) Accepting that any restriction on resource access has the potential to be inequitable. The intrinsic nature of Western capitalist economies is that any constrained resource will be traded to those who are best able to use it. The poor and the less capable are likely not to secure these resources. Sustainability strategies that do not directly embrace the challenge of social justice are likely to result in injustice. For this reason, any paradigm for the design of natural resource management strategy ought to have mechanisms for evaluating and dealing with potential injustice.

In considering the various issues addressed at the International Forum, it is hoped that it will help to prepare us to accept that merely having a set of instruments is not the same as having a strategy. The challenge is behavioural, and behaviour in relation to resources is complex and multi-faceted. If the impacts desired are to be made, then the reality of our own ignorance of how to deal with this challenge needs to be accepted. The task of deciding how to overcome this dangerous lack of real understanding of the fundamentals of the task at hand needs to be taken on.

To return to the Hans Christian Anderson analogy, the challenge is to somehow turn a strange collection of patches into a suit that will serve a purpose. It may never be perfect, and will require constant patching, but it may just serve the purpose.

References

Aalders, M., 2002. *Drivers and Drawback: Regulation and Environmental Risk Management Systems*. London, Centre for Analysis of Risk and Regulation at the London School of Economics and Political Science.

The Allen Consulting Group, 2006. *Transaction Costs of Water Markets and Environmental Policy Instruments: Final Report*. Productivity Commission, Melbourne.

Anderson, R.C., 2001. *The United States' Experience with Economic Incentives for Protecting the Environment*. Washington, D.C., National Centre for Environmental Economics: 254.

Argy, S. and M. Johnson, 2003. *Mechanisms for Improving the Quality of Regulations: Australia in an International Context*. Staff Working Paper.

Australian Bureau of Agricultural and Resource, E., 2001. *Alternative Policy Approaches to Natural Resource Management*. Australian Government.

Baldwin, R. and M. Cave, 1999.*Understanding Regulation: Theory, Strategy and Practice*. Oxford, Oxford University Press.

Bromley, D.W., 1997. "Rethinking Markets" in *American Journal of Agricultural Economics*, 79 (Proceedings Issue No. 5): 1383.

Brunner, K. and S. Pejovich, 1985. "The Limits of Economic Policy" in *The Economic Foundations of Property Rights: Selected reading*. Anonymous, Edward Elgar Publishing, pp.275.

Calcott, P. and M. Walls, 2000. *Policies to Encourage Recycling and 'Design for Environment': What To Do When Markets are Missing?* Washington, Resources for the Future, pp. 17.

Cary, J., T. Webb, et al., 2001. *The Adoption of Sustainable Practices: Some New Insights – An Analysis of Drivers and Constraints for the Adoption of Sustainable Practices Derived from Research*. Canberra, Land and Water, Australia.

Clinch, J.P., F.J. Convery, et al., 1999. "Economic Instruments for Sustainable Development: Improving the External and Working Environment Part I" in *Economic Instruments for Sustainable Development: Improving the External and Working Environment*. European Foundation for the Improvement of Living and Working Conditions.

Cole, D.H., 2006. "Towards 'Best Practice' Standards in Environmental Benefit-Cost Analysis" in *Social Science Research Network*, Sep 8, 2006.

Dovers, S., 2001. "Institutions for Sustainability" in *TELA: Environment, Economy and Society*, April (7).

Dragun, A., 1999. *Environmental Institutional Design: Can Property Rights Theory Help?* University of Queensland, Brisbane, Australia.

Driessen, D.M., 2003. *The Economic Dynamics of Environmental Law*. M5T Press, USA.

Eliadis, P., M.M. Hill, et al., 2005. *Designing Government: From Instruments to Governance*. McGill-Queen's University Press, Montreal and Kingston, Canada.

External Advisory Committee on Smart, R., 2004. *Smart Regulation: A Regulatory Strategy for Canada*. Canadian Government.

Ferraro, P.J. and R.D. Simpson, 2000. *The Cost-Effectiveness of Conservation Payments*. Discussion Paper: Resources for the Future, Washington.

Guerin, K., 2002. *Encouraging Quality Regulations, AI Theories and Tools*. Treasury: 1, Wellington, New Zealand.

Gunningham, N. and P.N. Grabosky, 1998. *Smart Regulation: Designing Environmental Policy*. Clarendon, Oxford.

Hannam, I. and B. Boer, 2002. *Legal and Institutional Frameworks for Sustainable Soils: A Preliminary Report*. IUCN, Gland, Switzerland.

Hutter, B.M., 2005. *The Attractions of Risk-based Regulation: Accounting for the Emergence of Risk Ideas in Regulation*. London, ESRC Centre for Analysis of Risk and Regulation, London School of Economics: 21.

Landell-Mills, N. and I.T. Porras, 2002. "Silver Bullet of Fools' Gold: A Global Review of Markets for Forest Environmental Services and their Impact on the Poor" in *Instruments for Sustainable Private Sector Forestry Series*. International Institute for Environment and Development, London.

Macher, J. T. and C.S. Boerner, 2002. "Transaction Cost Economics: An Assessment of Empirical Research in the Social Sciences" in *Journal of Law, Economics and Organisation*, 34 (2).

Martin, P. and M. Verbeek, 2006. *Sustainability Strategy*. Federation Press, Sydney.

Maser, S.M. and D.D. Heckathorn, 1987. "Bargaining and the Sources of Transaction Costs: The Case of Government Regulation" in *Journal of Law, Economics and Organisation* 3 (1): 69.

Moxnes, E, 2000. "Not Only the Tragedy of the Commons: Misperceptions of Feedback and Policies for Sustainable Development" in *System Dynamics Review* 16 (Winter): 325.

Niemeyer, S., 1998. *Consumer Based Carbon Reduction Incentives*. Centre for Resource and Environmental Studies, Ecological Economics Programme: 22, Canberra.

Sparrwo, M.K., 2000. *The Regulatory Craft: Controlling Risks, Solving Problems and Managing Compliance*. The Brookings Institute, Washington, D.C.

Stavins, R.N., 2001. *Experience with Market-Based Environmental Policy Instruments*. Discussion Paper. Resources for the Future, Washington, D.C., pp. 63.

Williamson, O.E., 1999. "Public Private Bureaucracies: A Transaction Cost Economics Perspective" in *The Journal of Law, Economics & Organization* 15 (1): 306.

Global Gender Issues and Sustainable Land Management

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Introduction

The Millenium Declaration and the Millenium Development Goals, agreed on by world leaders in the year 2000, recognize that a country's development cannot occur when the choices of women, some 52% of the global population, are constrained. Despite women's equal representation in the human population, their governmental representation stalls at a staggering 17.5% (International Parliamentary Union, 2007) in both parliament and senates. This global estimate differs at regional and country levels, with the highest parliament representation rates occurring in Nordic countries, but still only remaining at 41.4%. These figures not only reflect a low women's participation in public policy-making, but also provide a certain explanation and justification for the lack of appropriate consideration of gender issues in such policies.

The questions which will be addressed in this paper are the following: (i) why are these figures and considerations important for soil management; and (ii) how can the situation be improved.

1. Barriers to Women's Participation in Sustainable Land Management

Global assessments undertaken by the Food and Agriculture Organization (FAO) indicate that women are responsible for 60-80% of global food production, therefore representing key stakeholders in the management of land and soils (FAO, 2007). However, an analysis of women's participation in soil and land management demonstrates that their role remains constrained and limited. Current tools and practices applied by soil scientists, agriculture extension agents and policy-makers have failed to take into account the gender dimension. A global analysis undertaken by the United Nations Development Programme (UNDP) identifies the following key barriers as those preventing women's full participation in sustainable land management (SLM) practices (UNDP, 2007):

- Cultural issues: in certain societies, women cannot access extension services, simply because most extension agents – in the agriculture sector particularly – are males.
- The lack of value assigned to labour and subsistence of women constrains their access to credit, as they have no collateral to put against loans or credits. This is of particular importance in both post-conflict countries and African countries with high rates of death from HIV/AIDS; in these countries, households headed by women constitute the majority of households in rural areas. From a social point of view, this poses serious concerns for development, and from an ecological perspective, this implies that women can invest much less in appropriate practices, leading to extensive land areas under unsustainable management.
- Linked to this is the insecurity of tenure and access to finance; indeed, women are often pushed to the most marginal and least productive lands. In Eastern Europe for instance, women are predominantly involved in subsistence agriculture, while the more financially rewarding forest sector is dominated by men.
- Lack of opportunity to gain and share technical knowledge in SLM: The use of gender disaggregated data on literacy rates in Nepal indicates a difference of 30% (illiteracy rates in males are at 76%, while in females it stands at 46%). This highlights the need to explore innovative methods of extension services which often rely on print materials. Lessons of the UNDP Small Grants Programme in Latin America[1] on similar issues highlight the use of video and other pictorial modes as more effective means of communicating sustainable use techniques.

2. Means to Eliminate Discrimination Against Women

In line with the principles enshrined in the Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW), ratified in 2007 by 185 countries member to the United Nations, specific measures need to be undertaken for the full integration of gender considerations in soil and land related policies, programmes and approaches, as well as in budgetary and financial mechanisms.

Some of the approaches proposed by UNDP's gender and environment units – also advocated throughout the UN for strengthening gender involvement – include:

- *Disaggregation of data by sex, from problem identification to monitoring of impacts*: Planning documents, particularly logframes, are appropriate frameworks through which to introduce gender issues and indicators. However, while robust disaggregated data may be included at the planning stage, this is disregarded at the implementation stage and then later at the monitoring stage. For instance, women's effective participation in the development of local management plans cannot be confined to reporting the number of women attending a consultation workshop. Several subsequent steps need to be included, such as: proposals voiced by women at the workshop; proposals put forward by women that have been retained; proposals put forward by women that have been implemented. Unless this last step is undertaken, there are no means of determining the effective participation of women in a given process. Gender disaggregated data is also important for providing a good understanding of the system (spatial, temporal, administrative, ecological) in which one is operating. For example, in Micronesia, men are responsible for issues of the sea, and women for issues of the land. Therefore, any intervention that would not specifically target women is doomed to fail.

[1] www.sgp.undp.org

- *Specific measures for facilitating women's access to credit and resources*: Micro-credit experience from Asia demonstrates that women manage and reimburse their loans more reliably than men, provided they are given the opportunity to access them. The experience of the Grameen bank in Bangladesh constitutes a current example of such programmes: women are provided loans against a commitment to reimburse it from the income generated through their productive activities, and the conditionality of providing collateral is reduced to a minimum.

- *Special care should be taken to ensure that women effectively participate in processes*: Experiences in the Arab Region demonstrate the need to conceptualize consultation processes at times when women can participate – for example, by avoiding such times of day when children are at home and women need to provide for them. Similarly, experience from the Small Grants Programme in providing mechanical devices well-suited to women's physical constitution shows that it is necessary to adapt to women's particular requirements in order for practices to be adopted and applied.

At the 2007 International Forum on Soils, Society and Global Change in Iceland, global changes and trends and their impacts on soil conservation were discussed, as well as opportunities for improving the management of soils and stewardship approaches to land and ecosystems. Will these emerging changes fully embrace the gender paradigm and allow for an improvement of their situation, or will they further deepen the divide? If we look at access to carbon financing, access conditions and the attempts being made to include soil as a reliable and viable option for carbon capture, the question arises as to whether women's participation is being included in this emerging market. Reducing the transaction costs, the need for strong monitoring, and verification measures are at the forefront of this emerging market's preoccupations. Will the mainstreaming of gender considerations be taken into account as an additional measure, therefore increasing the transaction cost? Will these emerging markets embrace the concepts enshrined in CEDAW and therefore give due consideration to women both in their role as land stewards and equal beneficiaries of the financial resources generated by these markets, or will these markets miss the opportunity for levelling the playing field?

Several reports and assessments of the impacts of climate change indicate that, in the long term, climate change impacts may extend soil degradation to areas that are on the limit of sustainable use. Will the focus on curbing these impacts adopt a gender-sensitive approach to prevent the continued marginalization of women?

3. The Need for Gender Empowerment

With land stewardship and land care gaining popularity throughout the world and demonstrating the importance of locally-based solutions for sustainable land management, will due consideration be given to women, and in that context, can land care play a role in empowering women beyond the plot of land? Can and will land care open access for women to policies and decisions, to a better representation in our current societies' decision-making bodies at local, national and international levels?

The United Nations Convention to Combat Desertification (UNCCD) is the first of the three Rio Conventions to include specific language on women and the necessity of their full participation in the implementation of the obligations of the Convention. The United Nations Convention on Biological Diversity, under its cross-cutting issues on Traditional Knowledge, Innovations and Practices, and Access to Genetic Resources and Benefit-Sharing, also recognizes that women are the keepers of ancestral knowledge. The importance of such traditional knowledge in sustainable land and ecosystem management has been proven and codified by research undertaken by academia, international organizations and non-governmental organizations[2]. Such traditional knowledge does not only encompass practices and tools for sustainable land management, but it also provides us with the necessary wisdom to do so.

A Nordic tale reminds us of the key principles that will fully enable gender empowerment. It is told that Thor, a Nordic God, was tested by the council of Gods to determine whether or not he was worthy of a God status; he was confronted with three situations:

1) In trying to access a grotto, he was confronted by a raging monster. While his first reaction was to retaliate and attack, he then realized that this monster was a mother protecting her newborns. Understanding the situation, he turned around and let it be.
2) He was then put on a white sandy beach. It took him some time to realize that every grain of sand he crushed resulted in the extinction of a star in the sky. Realizing that he was part of a connected system, he became cautious not to affect his surroundings.
3) For the third test, he was confronted by a village of starving people asking him for food. This is where he failed the test by using his powers to provide them directly with food rather than teaching them how to produce food.

This tale, as with many others in our collective wisdom, underpins that compassion and empathy, a full understanding of the system in which we operate, and genuine capacity-building measures are key principles for successfully addressing gender issues in sustainable land management.

[2] In reference to work undertaken by the UN Convention on Biological Diversity, UN Convention to Combat Desertification, Winrock International and USAID.

References

FAO, 2007. FAO Focus: Women and Food Security. Available at: http://www.fao.org/focus/e/women/Sustin-e.htm.

International Parliamentary Union: Women in National Parliaments, http://www.ipu.org/wmn-e/world.htm.

UNDP, 2007. Mother Earth: Women and Sustainable Land Management. Gender Mainstreaming Guidance Series, Environment and Energy Group, New York.

Forum Reports

Forum Rapporteur's Overview

Roger Crofts, IUCN World Commission on Protected Areas & Commission on Ecosystem Management

Introduction

From the scientific evidence available, it is clear that societies around the world have mismanaged soil over many generations. As a result, in many parts of the world soil has been lost at a rate greater than its formation and its natural functions have been diminished and degraded. Soil is no longer as productive as it naturally can be. Soil does not act effectively as a store of water and of nutrients. Soil is less resilient to natural events of floods and high precipitation. Soil has lost a great deal of carbon and other critical components to the atmosphere and to the oceans. Soil now has a reduced capacity for carbon storage and is less able to act as a buffer against climate change.

It is suggested that many governmental institutions and global initiatives and processes have failed to recognize the importance of soil to society. If the soil management objectives of international agreements, such as the Millennium Development Goals and those goals agreed to under the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD) and the United Nations Convention on Biodiversity (UNCBD), are to be achieved, then individual nations should work more closely with international organizations on the management of soil and the restoration of degraded land.

The situation is urgent. The global community has set ambitious targets for poverty alleviation and improved access to clean water, among others, through the Millennium Development Goals. Many commentators, including the global community of climate experts, consider that similarly ambitious targets are required in the reduction of greenhouse gases to help combat global climate change. At present, the trends on these issues are progressing in the wrong direction and in too many parts of the world soil stewardship and land restoration are making limited progress. Without agreement on action and urgent implementation, the position of this vital natural and social resource will deteriorate further.

Traditional approaches developed in the industrialized world have been inadequate to meet the challenges facing us today. These approaches tend to be top-down, politically motivated, superficial, with available financial resources misallocated, and are not based on the best scientific, technical and traditional knowledge available.

A new vision is needed that places soil at the heart of global social, economic and environmental solutions. This vision should recognize the dependency that nature and human society have on the functioning and productivity of the soil. This means greater recognition of the necessity for better stewardship in order to combat detrimental global environmental and social changes. This will require a new ethic of land stewardship, new policies, improved instruments, improved resource management and better targeted financial support. These, in turn, will require increased political support, financial commitment and the application of improved scientific and technical knowledge.

If greater care and stewardship of the soil and a greater emphasis on soil and land restoration can be achieved, then many benefits will result. Such benefits include: reduction in the loss of the soil resource; increased soil organic matter and nutrient status; improved food and fibre productivity; increased water storage capacity and water availability; reduction in flooding and erosion; and, increased capture and retention of carbon and other greenhouse gases, among others. If this action is taken, it will contribute to a reduction in poverty, improved land productivity, greater access to water resources, reduction in the loss of biodiversity, reduction in emissions that contribute to global climate change, and improvement in environmental and food security.

1. The Forum Plenary: Key Issues

This summary is based on the presentations and discussions during the Forum and was presented to the final plenary as a Forum Overview by the Forum Rapporteur.

Two contrasting perspectives emerged from the plenary. The first concerned the negative trends in soil and land degradation and the associated effects on human well-being. The second concerned more positive opportunities for addressing and improving the situation. Although there was no systematic assessment of the situation across different continents, the material presented highlighted the challenges apparent in the regions of Africa south of the Sahara, in parts of Asia, and parts of Latin America, where the interconnections between soil, land degradation and poverty are most markedly negative.

1.1. Negative trends and their consequences

A number of headline messages concerning negative trends and their consequences were presented. The following are those which resonated most with the participants of the Forum:

- The Poverty Trap: the Downwards Spiral of Land Degradation and Human Poverty
- The Tragedy of the Environmental Commons

The key points that emerged on negative trends were that, at the very least, 10% of the world's drylands are suffering from severe land degradation. Some estimates put the level of land degradation as high as 70%. One of the major natural consequences of this degradation has been that an estimated 60-100 billion tonnes of carbon has been lost from the soil during the course of human history.

In addition to poor husbandry and poor stewardship of the soil, a number of other reasons were put forward as the causes for the level of degradation. There has been a preponderance of single solutions, whereas land degradation requires a much more multi-faceted and complex approach. The position is made even more complex because there is confusion about what are the causes and what are the effects. Indeed, the best that can be said is that there is confusion between cause and effect, complicated even further by many feedback loops. The drivers of changes in soil and land degradation vary radically in type and effect over time. Overall, agricultural production is frequently considered to be the main and dominant driver; however, it is regarded as too strong an influence by some. Many of the approaches used to combat soil and land degradation have been top-down and have failed to engage the local stakeholders who own and manage the land, and local communities whose lives and livelihoods depend upon it. At the same time, there has been a loss of what is commonly referred to as a 'land ethic', and also a loss of traditional knowledge. Many new solutions have been developed and introduced, but they have not always been successful because some have been ill thought-out or over-simplistic. Also, grave doubts were expressed about the efficacy and ethics of market mechanisms.

The scale of soil and land degradation is not at all clear, as the figures indicated above illustrate. This means that targeting action is extraordinarily different. Also, many different methodologies have been used and there is no compatibility between them; hence, comparative assessments are not possible. This situation becomes critical for the world's drylands, as there is no agreed definition of desertification; the Forum identified this as a point for urgent activity but did not come to any agreement on a new definition.

Despite the amount of international attention given to various environmental issues, there is a great deal of separate and uncoordinated activity. Speakers observed that the three key UN Conventions (Desertification, Climate Change and Biodiversity), are not integrated and operate as separate entities. As a result, there is a need for more coordinated efforts that, in part, focus on soil as a major component relevant to each Convention and to achieving the Millennium Development Goals.

There is a recognition that the message about the importance of soil to society's well-being is not getting through to wider audiences, including key decision-makers in the international environment and development arenas. The responsibility clearly lies with the soil and soil conservation expert community to ensure that their message is being more effectively communicated.

1.2. Reasons for hope

Despite the many negative aspects of soil and land degradation identified by speakers, many optimistic points were raised.

The headlines which resonated with delegates were:

- Trust in the Soil
- Soil is the Common Denominator
- Soil is at Heart of the Sustainable Development Debate

There was a strong consensus that a new paradigm on soil and land restoration is needed if the current negative trends are to be reversed and if instruments are to become more effective. This new paradigm should contain ethics and societal values as major components. There was also recognition that a more anthropocentric approach was needed rather than a purely technocratic or environmental approach. Putting people at the centre of new solutions was seen as essential. Integrated and holistic approaches are needed to define synergies, identify multiple goals, and engage the whole range of stakeholders. Land custodians and local communities are key actors in defining and delivering new solutions.

There was a recognition that new mechanisms and techniques can help to provide solutions. Among the suggestions made were: models to identify thresholds between sustainable and unsustainable trends; a systems approach for understanding interconnections between many variables; and economic analysis to define costs and benefits (including whole life cycle environmental and social costs). Also, there was widespread recognition of the need to learn from mistakes as well as successes, and to apply practical solutions relevant to circumstances. It was also considered necessary to operate and to find solutions at a scale commensurate to that of the problems; this could be at the local community, catchment, national, regional or global level, depending on the issue in question and the solutions proposed.

Environmental markets, voluntary and/or enforced, were considered to provide opportunities for solutions, despite difficulties experienced. Carbon capture and carbon trading schemes may be the most innovative solutions for soil restoration and improving the productivity of the land.

2. A New Paradigm

Reflecting on the points that emerged from the plenary and the ensuing discussions, the Forum Rapporteur proposes a New Paradigm:

"Soils for the Sustainable Health of Our World: achieving acceptance of healthy soil as a fundamental component of human life – an ethical, value-driven and practical approach at the core of a new Global Covenant"

Key elements of the New Paradigm are:

- There is no one driver and no one solution, and therefore no all-encompassing golden bullet solution.
- Any solution must recognise the complex interrelationship between drivers.
- Whole ecosystem approaches are needed, with humans as a constituent part.
- Soil sustainability through restoration and improved stewardship results in many benefits, including climate change amelioration, poverty reduction, water retention, and reduction in biodiversity loss.
- Any solution must recognise that land degradation and the poverty trap are interlinked in complex ways, and the solution lies in breaking this negative cycle and replacing it with a more positive one.
- The results from scientific studies should be made accessible to local communities, key actors and other members of the public.
- Options for sustainable land use, including a new future for farmers, should be elaborated.
- Better interactive approaches with a greater focus on local solutions with effective knowledge management and transfer are required.

3. Agenda For Action

The principal areas for action identified during the course of the Forum have been classified under the following headings and are further accompanied by a description. These action areas complement the Programme for Action (p.192) agreed upon by the participants and suggest a way forward beyond the Programme for Action.

For each of these actionable items identified by the Forum Rapporteur, the following points need to be addressed: defining the issue; identifying the action needed; who takes the lead and who provides support; and, the timescale for realisation. A draft for each action is proposed.

3.1. Making the case for soils and society

Under this umbrella action area, the following actions are proposed:

a) International Forum on Soils, Society & Global Change Programme for Action

The Programme for Action (p.192) was developed in order to gain attention of opinion farmers and leaders, to promote the need for integrated approaches, and to link soils to the global agendas on climate change, poverty reduction, and biodiversity. The Organizing Committee of the Forum was tasked with disseminating the Programme to international institutions.

b) Developing and promoting a New Paradigm for soil stewardship

A New Paradigm is proposed as a way to ensure that soil stewardship is universally recognised as part of an integrated solution to global well-being. It was proposed that the further development of this new paradigm should be undertaken by an ad hoc group led by Ron Engel, and that it be widely disseminated, both globally and locally, as a contribution to a new global Earth Covenant.

c) Round-table on Soils, Society & Global Change

In order to stimulate political commitment, financial support and global action on soil stewardship and land restoration, especially in those parts of the world where human need is greatest, it is proposed that the President of Iceland convene a high-level round-table discussion involving key global stakeholders, such as governments, the business community, the scientific community, environmental leaders and civil society participants. It is hoped that this discussion will lead to transformation of the enabling environment, leveraging of financial resources, and improvement of market conditions. The Forum Organizing Committee with the President of Iceland should move this activity forward.

d) Advocating for a UN Year of Land Care

In order to raise the profile of soil stewardship and land care globally, the feasibility of declaring a UN Year of Land Care should be evaluated in consultation with national governments, as support from national governments is needed in order for a proposal to be submitted to the UN General Assembly. It was suggested that a sub-committee is formed, involving members from the Working Group on Soil Stewardship and Landcare of this Forum, representatives from the Secretariat for International Land Care, and other interested participants, in order to move this item forward.

e) Amendment to the Earth Charter to include soil protection

Forum participants noted that soil protection was a major missing component in the Earth Charter. It is proposed that an amendment to the Earth Charter to include soil protection be drafted and to seek agreement from the Charter’s guardians. It is proposed that Ron Engel lead this development.

f) Enlightening the interconnections.

Forum participants identified a confusing circularity and downward spiral between the causes and effects of soil and land degradation, ecological and human health and well-being. It is therefore proposed that a systematic approach to challenges be developed which will address the interconnections between water, climate change, land productivity and biodiversity. This activity should be initiated through a joint agreement by the Secretariats of relevant international Conventions. Relevant experts should be commissioned to undertake the task.

3.2. Making the UN Conventions connect

Through the following action items, Forum participants are keen to see increased synergy and enhanced cooperation between the UN Conventions and their Secretariats, and increased coherence between sustainable development and achievement of the Millennium Development Goals.

a) Invite the Intergovernmental Panel on Climate Change (IPCC) Secretariat through the UNCCD to develop a special report on land degradation and climate change.
b) Establish an ad hoc Group of Experts selected jointly by the three UN Conventions with the task of identifying the synergies and linkages between the Conventions.
c) Each Convention should establish a certification mechanism on soil stewardship for all of its policies, activities and projects related to soil.
d) The UNCBD should develop an approved work programme on agricultural biodiversity.
e) Encourage national governments partied to the UNCCD to undertake their responsibilities on the protection and sustainable use of soil.

3.3. Developing the instruments and mechanisms to ensure that the improved outcomes are achieved

a) Improvement of the carbon market

It is proposed that the workings of the carbon market be improved in the following ways in order to provide further incentives for land restoration through the Clean Development Mechanism: reduction of transaction costs; standardisation of methodologies for monitoring and verification of greenhouse gases in land restoration; promotion of voluntary certification systems; engagement of the insurance sector; and, development of a certification scheme.

b) Develop a binding international instrument on the protection and sustainable use of soils

It is proposed that an international legal instrument is developed and agreed to under the auspices of the UN to obligate all nations to undertake actions to ensure that national soil resources are properly protected and cared for, so that the productivity of the soil can be sustained in perpetuity.

c) Conclude the development of guidelines for national legislation on soils

The work by the International Union for Conservation of Nature Commission on Environmental Law Specialist Group on Sustainable Use of Soils and Desertification should be concluded and the results disseminated to all governments.

d) Develop guidelines for national legislation on the treatment of contaminated soils

The IUCN Commission on Environmental Law Specialist Group on Sustainable Use of Soils and Desertification should be invited to draw up guidelines for legislation on contaminated soils that can be used in the drafting of legislation in all nations.

3.4. Increasing the knowledge base

a) Invite the IPCC to develop an assessment of land degradation and climate change
b) Develop a common methodology for assessing soil and land degradation

During the Forum, participants recognised that there is disagreement on the scale and severity of land degradation, which in turn affects the overall credibility for making a case for action against it. Furthermore, participants agreed that there is currently no consistency in the methodologies of assessment. It was proposed that a standardised methodology for defining land degradation is developed with the flexibility to meet different objectives. It was also suggested that a definitive statement on levels of degradation in different biomes and in different continents, on soil ecosystem functionality, and on the valuation of social and economic aspects of land degradation and restoration be developed. This development would be jointly led by, among others, experts from the United Nations University, the Agricultural University of Iceland, and The Ohio State University.

c) Update data sets and create harmonised methodologies which are properly funded and accredited and made widely available, particularly those at the Food and Agriculture Organization and the United Nations Environment Programme.
d) Initiate the creation of a report by the United Nations Environment Programme and the Global Environment Facility on land restoration and climate change.

e) Redefine desertification.

3.5. Action on the ground

a) Develop a soil and land restoration outreach programme

It was proposed that an integrated programme in key African and Indian sub-continent countries be developed in an effort to raise awareness and undertake action on land restoration, including actions on capacity-building and carbon sequestration. It was suggested that Rattan Lal lead the development of this initiative and that it be developed in consultation with the members of the proposed high-level round-table discussion.

b) Develop guidelines on land care

Over the last 25 years, the guiding principles for improved soil stewardship have been developed across a number of countries in the form of a range of participatory approaches at the local level under a broad umbrella called Land Care. Land care focuses on empowering local people to willingly take action on local soil stewardship issues and integrating these into the broader issues relating to land resource use and management. These activities are strongly commended and have resulted in a breakthrough on soil stewardship in many parts of the world. There is now a need to disseminate these good practices widely and to use them as a basis for developing specific guidelines applicable to different regional and national circumstances and opportunities. Landcare International might wish to consider taking the lead on this activity.

c) Define the choices for land use beyond agriculture

It was recognised that though the use of land for food and fibre production must continue, the income stream from this activity influences soil and ecological integrity. It was recognized that other opportunities for land use need to be identified, and it was proposed that this could be done through a review paper on options for the use of land care and development of guidelines on how to make choices on land use. And ad hoc working group led by the Food and Agriculture Organization was suggested.

d) Develop a portfolio of pilot projects for carbon trading

3.6. Building capacity

a) Undertake effective communication and capacity-building on carbon financing programmes through clearing house approaches
b) Develop an informal network of practice on land care
c) Involve businesses through the World Business Centre for Sustainable Development
d) Establish a knowledge base of lessons learned from capacity-building
e) Establish ways for the scientific community to make knowledge available to key stakeholders in an accessible manner

4. Forum Message

The overall message that emerged from the Forum was the importance of soil and its interconnection to other key environmental and development issues. Soil is a critical component of ecological processes and biodiversity and cannot be forgotten. Through better stewardship of the soil, and better recognition worldwide of its importance and its many linkages, we can better address the many other environmental and development challenges we face today. The care of the soil is vital to the well-being of society now and in the future.

Don’t forget the soil. Through its stewardship by society throughout the world, it provides essential food and fibre, it acts as an important water store, it is the filter for pollutants, it is a vital carbon store, and it is a critical component of ecological processes and biodiversity. The care of the soil is vital to the well-being of society now and in the future.

Working Group 1: Soil Stewardship and Land Care

Chair: Andrew Campbell, Triple Helix Consulting, Australia
Rapporteur: Ingibjörg Elsa Björnsdóttir, Environmental Consultant, Iceland
Assistant to the Rapporteur: Hafdis Hanna Aegisdóttir, Icelandic Land Restoration Training Programme

Introduction

The objective of Working Group 1 was to discuss the land care approach to soil and land conservation and management, and to arrive at a series of recommendations for the development of guiding principles on soil stewardship and land care. The discussions reflected upon the content of the plenary presentations and their implications for the topic of this Working Group.

The ethics and good practices of soil stewardship offer a crucial tool in reaching global development goals, such as doubling food production by 2050, reducing poverty, and providing access to clean water, as well as global environmental goals, such as reducing the loss of biodiversity and the effects of climate change and land degradation.

Improving soil stewardship is an inherently grassroots activity. While it could undoubtedly be helped by high-level scientific breakthroughs and fostered through supportive institutional arrangements both from governments and markets, the vast majority of soil management decisions are taken at the level of the plot, the field and the farm.

Over the last 25 years, the guiding principles for improved soil stewardship have quietly been developing across a number of countries in the form of a range of participatory approaches at the local level under a broad umbrella called Land Care. The Land Care initiative provides a perfect opportunity for improving and promoting soil stewardship and for fostering learning and innovation at a community level.

Summary Report

The Working Group especially considered:

1) The potential of Land Care as a land stewardship model, and how best to share and learn from the experiences and insights emerging from Land Care activities around the world.
2) Key principles and lessons learned that could form the basis for a set of guiding principles on land care and stewardship. Some such elements are listed at the end of this report.
3) On strategies for land care promotion, the group especially focused on the issue of land literacy, namely, developing practical educational tools to help people to listen to and understand the land. It was strongly felt that land literacy programmes targeted at children have a huge role to play in long-term approaches to improving soil management, and that successful examples have a great potential to be widely promoted.
4) Potential linkages between, and opportunities for, incorporating land care principles into international processes, including the Multilateral Environmental Agreements (MEAs).
5) The establishment of a group of people, such as an international Community of Practice in Land Care, to share experiences and lessons.
6) The possibility of establishing an International Year of Land Care.

Working Group 1 discussed how to best share and learn from experiences and insights emerging from Land Care activities around the world. It identified measures that would have an impact on making the lessons and insights from the rich diversity of land care activities around the world accessible for a much wider audience, and measures that would assist in promoting the concept of land care worldwide.

On the basis of their discussions, the following key issues emerged (see Table 1):

1) The need to strengthen approaches for sharing experiences, lessons learned and building knowledge in land care.
2) Soil stewardship and land care need a set of guiding principles, to be disseminated and implemented internationally.
3) Soil stewardship and land care need to be promoted more widely, as do efforts for building capacity and sharing knowledge and experiences related to these issues.
4) The importance of practical education programmes for helping people to “read the land” and to manage their soils.

Key Recommendations and Plan of Action

Working Group 1 developed the following list of recommendations and a plan of action for improving soil stewardship and land care internationally (Table 1).

Table 1. Key issues, recommendations and plan of action on improving soil stewardship and land care internationally.

Key Issue	Recommendations	Plan of Action
The need to strengthen approaches for sharing experiences and lessons learned and for building knowledge in land care practices.	That an informal group of practitioners in land care approaches be developed as an International Community of Practice aimed at addressing these needs.	This recommendation should be progressed with the International Land Care Association and other interested bodies, such as the World Association of Soil and Water Conservation. This Community of Practice would play a leading role in developing the knowledge base and promoting guiding principles and practical approaches to soil stewardship and land care, such as land literacy tools.
The need for a set of guiding principles and international standards for soil stewardship and land care.	That a set of guiding principles for Soil Stewardship and Land Care, be developed and promoted as part of a knowledge base on these issues.	The Community of Practice would further develop the first cut principles discussed by WG 1 (a cursory list is provided below) into a set of guiding principles. This could then feed into awareness raising and education and training activities preferably through joint initiatives across the three UN Rio Conventions.
The need for increased global awareness and promotion of an ethic of soil stewardship and land care, and for focusing efforts to build capacity and share knowledge and experiences.	That the feasibility of an International Year of Land Care, proclaimed by the United Nations, be further investigated beyond this meeting.	The formation of a sub-committee involving members from WG 1 of this Forum, representatives from the International Landcare Association and representatives from the Secretariat for International Land Care, to further explore possibilities with the relevant formal UN mechanisms for the establishment of an International Year of Land Care.
The importance of improving management of the world's soil resources through practical education programmes using land literacy tools and approaches, especially targeted at children, to help people "read the land".	The establishment of a knowledge base on Soil Stewardship and Landcare, which would include, *inter alia*, good quality materials on land literacy education, and training programmes and tools.	The international Land Care Community of Practice would assemble and organize existing material on land literacy education programmes, and develop it further and promote it as an essential part of a long-term solution for sustainable land use.

With regards to the development of a set of guiding principles on soil stewardship and land care, Working Group 1 discussed several key principles and lessons learned that could form its basis. Among the core elements that should be included are:

- The notion of the integrity and stability of the land community, based on Aldo Leopold's Land Ethic statement.
- Avoiding the imposition of hierarchies or divisions between stakeholders.
- To have a more collective mind frame: there is no "us" and "them", only "we".
- The issue of knowledge management and transfer: changing it from a top-down approach to one that is bottom-up.
- Encouraging people to communicate amongst themselves.
- Start education and training early, for example, with children.
- Work with and reinforce the way that land users (such as farmers) feel about their land; don't work against it.
- Use a step-by-step approach to build confidence and trust, especially in developing countries, and allow time for building trust. Begin with locally-generated technology and then look at other elements to be incorporated.
- Maintain personal integrity and that of the land. Don't endorse practices that degrade the land. Respect traditional knowledge.
- Be wary of focusing on a single issue, especially if value is assigned to just one component of the system (e.g. carbon) that will usually lead to other components becoming devalued.
- Think about all land users, not just farmers. The whole economy impacts on the land, and in many places, land is now being managed by interests other than farmers. This can bring big opportunities, but new land users may not bring a land ethic with them.

Though this is only a cursory list, it does provide valuable guidelines that should be taken into consideration when developing a set of guiding principles.

Conclusion

Working Group 1 hopes that the recommendations and outputs that emerged during their discussions (Table 1) will lead to an increased and extensive international exchange of knowledge, contacts, ideas, energy and resources on soil stewardship and land care. Working Group 1 believes that these recommendations could form the basis for a valuable contribution in helping the global community to meet the unprecedented learning and food production challenges it faces.

Working Group 2: Soil Management for Promoting Synergies in the Implementation of the Three United Nations Rio Conventions

Co-Chairs and Co-Rapporteurs: Luca Montanarella, European Commission; and Youba Sokona, Sahara and Sahel Observatory
Assistant to the Rapporteurs: Páll Valdimar Kolka Jónsson, University of Iceland

Introduction

The aim of this Working Group was to discuss and arrive at a series of recommendations on how to encourage increased synergies on land and soil management issues in the implementation of the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention on Biodiversity (UNCBD), and the United Nations Convention to Combat Desertification (UNCCD). In particular, this working group focused on identifying options and possible joint initiatives for preventing and/or reversing land and soil degradation through the implementation of the three Conventions. The Working Group concentrated on the following two major tasks:

- To identify scientific and technical issues common to the three Conventions which have a bearing on soil management and which could facilitate sustainable development and the achievement of the Millennium Development Goals (MDGs); and,
- To identify tools and instruments that can facilitate the effectiveness of the implementation of the Conventions through soil management.

Summary Report

This group especially considered:

1) The institutional arrangements in place at the national and international levels of the three Conventions; the eventual possibilities to improve their interrelationships with respect to soil management; and, what contributions could collectively be made to more effectively tackle sustainable development issues to achieve the MDGs and to overcome the various problems raised in relation to the operation of the Multilateral Environmental Agreements (MEA).
2) The scientific aspects of land and soil management common and/or relevant to the three Conventions, and the adaptation of strategies based on sound management of land and soil.
3) Tools and/or instruments already developed in a specific Convention and relevant to the implementation of the two others Conventions.
4) Means to have soil scientific issues more effectively addressed in the three Conventions.
5) Whether a special report of the Intergovernmental Panel on Climate Change (IPCC) on land and soil management issues should be recommended in order to identify synergies and trade-offs between the three Conventions.
6) The recently released IPCC reports and the related priority areas for future action in order to adapt to climate change, particularly in drylands.
7) The means to evaluate global and local benefits of improving and/or preventing land and soil management.

Participants first discussed the history of the term “synergies” in the context of MEAs and whether this term implied something different than “cooperation”. They then discussed potential differences between environment- and development-oriented conventions, noting that the UNFCCC and the UNCBD are largely the former, while the UNCCD has traditionally been regarded as the latter. Most participants agreed that general efforts to increase synergies between the Rio Conventions should address sustainable development and attainment of the MDGs. They also reached an agreement on the value of developing a common scientific understanding of how soils relate to land degradation, desertification, biodiversity and climate change.

On the basis of these conclusions, Working Group 2 considered potential recommendations to encourage sustainable soil management as part of a broader process of enhancing cooperation in the implementation of the Rio Conventions. Several key ideas emerged:

1) The possible development of a Special Report on land degradation and climate change by the IPCC that would take into account the global dimension of soil degradation.
2) The development of a “Soils Synergies Assessment Report”, based on the proposed IPCC Special Report and other existing documents such as the IPCC Special Report on Biodiversity and Climate Change.
3) The development of guidelines on implementing the Rio Conventions with respect to soils, with the guidelines being aimed at the national focal points of each Convention and at donors.
4) The development of a voluntary certification scheme for project proposals that would indicate when a project jointly serves the aims of all three Conventions, in order to give greater visibility to synergies at the implementation level.

Finally, participants discussed the lack of local-level awareness about MEA synergies and hence the need to invest in grassroots awareness-raising, training and education on synergies. The Working Group developed the concept of a “training-the-trainers” programme that could complement and promote existing education initiatives on synergies.

Key Recommendations

Working Group 2 recommends strengthening cooperation in the implementation of the Rio Conventions on the ground. In this regard, it specifically recommends:

(i) That the Committee on Science and Technology (CST) of the UNCCD recommends to the UNCCD Conference of the Parties (COP) to request the IPCC to prepare a Special Report on Land Degradation and Climate Change, taking into account the global dimension of soil degradation.
(ii) That the CST recommend to the UNCCD COP that the UNCCD Secretariat make contact with the CBD and UNFCCC Secretariats in order to establish, under the authority of the Rio Convention Joint Liaison Group, an ad hoc Group of Experts to carry out an assessment of existing documents dealing with linkages between the subject matters of the Rio Conventions, recognizing that soil is a key linkage point between them.
(iii) That the ad hoc Group of Experts be mandated to compile, on the basis of its initial assessment, guidelines, targeted at donors and national focal points for the three Conventions, regarding implementation of the Rio Conventions on the ground.
(iv) That each Convention develop certification criteria in its own Convention regarding the subject matter of the other two Conventions to be used as guidelines for project proposals in order for projects to maximize added value.
(v) The strengthening of information dissemination to stakeholders on the ground about the added value of linkages between MEAs through the launch of a "Training the Trainers Programme" and through further promotion of existing initiatives.

Plan of Action

Working Group 2 proposes the plan of action outlined below (Figure 1).

The aim is to bring together the science behind the MEAs into a coherent approach to soil management within the UNFCCC, UNCBD and UNCCD. The plan proposes that the CST of the UNCCD initiates a dialogue with the Conference of the Parties to ask them to take the necessary steps towards the preparation of a special report by the IPCC addressing "Land Degradation and Climate Change" in a comprehensive assessment, taking into account all the existing knowledge on land degradation, climate change and soils, and covering all aspects relevant to each of the three Conventions. At the same time, it is proposed that the ongoing discussions are further enhanced within the Joint Liaison Group (JLG) between the Secretariats of each Convention by establishing a small Group of Experts (GOE) operating in a similar manner as the IPCC. This group would be mandated with the preparation of a specific report on the possible synergies among the three Conventions in relation to soil protection and sustainable soil management.

Both initiatives should ultimately lead to the preparation of practical guidelines for the respective National Focal Points of each Convention, with an aim of the ultimate implementation at the local level and on the ground. Sustainable development projects should recognize that soil is a key linkage point between the focus areas of each Convention.

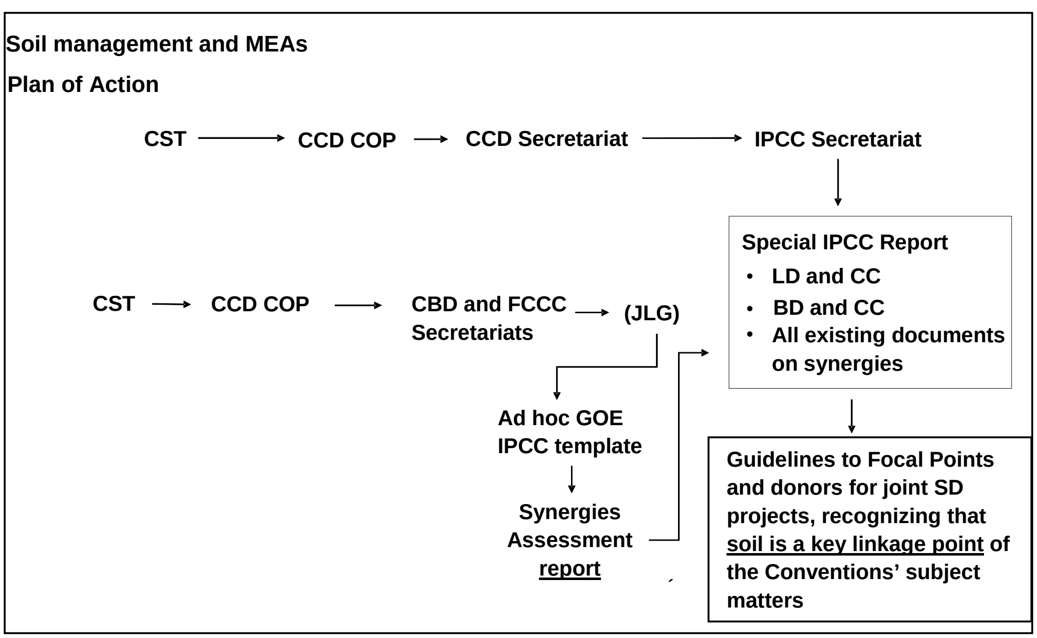

Figure 1. Proposed plan of action by Working Group 2 for promoting synergies in the implementation of the three UN Rio Conventions.

Working Group 3: Carbon Sequestration and Land Restoration

Chair: Bal Ram Singh, Norwegian University of Life Sciences
Rapporteur: Mirey Atallah, UNDP/GEF Regional Coordination Unit for Arab States
Assistant to the Rapporteur: Julieta Muñoz, University of Iceland

Introduction

The aim of this Working Group was to discuss and arrive at recommendations for lifting barriers to help transform the carbon market in order to facilitate equitable and ethical carbon trading, and in order to meet expectations of 10-20% sequestration of global carbon emissions through land restoration. The Working Group, consisting of 20-25 scientists, administrators and policy-makers, took the following points into consideration:

1) Land restoration, that is the rehabilitation of degraded lands to a functioning and stable ecological state, has an important role in mitigating climate change and in generating multiple benefits.
2) The Clean Development Mechanism (CDM) of the Kyoto Protocol, state-mandated and voluntary markets are important but imperfect tools.
3) Developing countries and their economies, people and ecosystems should be the main financial beneficiaries of carbon projects.
4) The involvement of developing country organizations at the regional and national levels should be mandatory in the development and implementation of carbon projects.

Summary Report

This group articulated the following aspects of carbon sequestration and land restoration issues according to four strategic areas:

1) Improving practices and risk management

There is a need to ensure coherent regulatory frameworks for land restoration projects benefitting from carbon finance, including:

- Monitoring and assessment: Despite the progress made in understanding the dynamics of soil carbon and tools for assessing and monitoring carbon sequestration, there are still large knowledge and technological gaps that need to be filled. There is a need for public investment in common methodologies for monitoring biomass carbon and other greenhouse gases (GHGs) for: project use/application; calibration and testing of tools at the local level; and modelling and scaling up of information at the national and global levels; among others.
- Risk management: The current practice of a too narrow focus on carbon trading carries a risk of undesired effects. Other values, such as water, biodiversity and social justice, must be taken into account in the design of carbon markets and instruments. This should include strategies to: (i) assist local producers and land users to access capital up-front for investment in land restoration by providing incentives to the banking sector and/or brokering deals with the potential buyers; (ii) encourage indexed insurance schemes for bio-sequestration and land restoration projects; (iii) encourage the bundling of credits at different levels through a collection of individuals or a common property system, nationally or at other levels; special care should be given to ownership issues, institutional issues (cooperatives), and avoiding monopolies and gatekeepers; (iv) in order to reduce risks and maximize benefits to local land users, environmental and social safeguards should be developed and rigorously applied in a participatory manner.

Keeping in mind that societal and ecological value supersedes any economic benefits that may be generated from carbon finance projects, these safeguards and measures to improve practices and risk management should be systematically applied at project levels to preclude any negative impacts of carbon projects.

2) Effective communication and capacity-building

Capacity development needs constitute a key barrier to the development of carbon projects in developing countries or result in the alienation of national stakeholders from the process. Emphasis must be placed on the need to build the necessary capacities at individual, institutional and systemic levels, which will bear additional benefits to the respective countries. In particular:

- Technology needs to be adequate and accessible to developing country organizations (i.e. web portals, communication tools, measurement and monitoring, etc);
- Local expertise in developing countries for design, monitoring and verification needs to be developed;
- The national capacity to organize, assimilate, integrate and archive data on soils, forestry, etc. needs to be developed;
- Pilot projects need to be designed and implemented as learning-by-doing mechanisms, with associated learning and dissemination mechanisms;
- Awareness and commitment of socially responsible corporations and investors needs to be generated in order to capture the societal values of bio-carbon and land restoration projects.

3) Lifting barriers to transform the carbon trading market

Current regulatory structures inhibit the development and implementation of land restoration and carbon sequestration initiatives; in particular, the transaction costs resulting from the current monitoring and verification as well as pricing and payment systems prohibit the development of such projects in developing countries and particularly in least developed countries (LDCs). It is therefore necessary to:

- Broaden the market to include a flexible range of instruments;
- Encourage the CDM to modify certain requirements in an effort to provide further incentives for land restoration and carbon sequestrations in terrestrial ecosystems by: (i) increasing the limit of small-scale projects so as to reduce per unit transaction costs; (ii) expanding the eligible land use, ecosystem and project types into the Land Use, Land-Use Change, and Forestry (LULUCF) category; (iii) reducing high transaction costs by rationalizing the requirements for adequate precision, accuracy and frequency in monitoring and verification for bio-projects because of high transactions costs, without losing accountability; and, (iv) recognizing that the expiring credits bring flexibility to the market, and that the rule of retirement after 60 years should be reconsidered.
- Enhance integrity and credibility of institutions involved with the market so as to maximize revenue benefitting land managers.

4) Obtaining recognition of the multiple benefits of land restoration

Carbon sequestration through land restoration generates associated benefits such as increasing agricultural productivity, combating desertification and maintaining biodiversity through soil, water and ecological quality improvement, among others. It is essential that:

- The societal value and ecosystem services of land restoration and bio-sequestration projects be recognized by the carbon markets, and that a premium price be offered for them.
- A common system of certification and verification for calculating premiums without additional transaction costs is developed.
- Revenue generation from a combination of carbon with other associated benefits, such as certification of production, payment for ecosystem services, timber certification, government subsidy, etc., should be encouraged.

Key Recommendations and Plan of Action

In concluding its deliberations, Working Group 3 made the following recommendations:

1) There is a need to strengthen the understanding of processes, properties, practices and measurement of carbon sequestration in terrestrial ecosystems in order to open up the carbon markets – including state-mandated, CDM and voluntary markets – and in order to maximize benefits to local land users.

2) Donor organizations need to strengthen the enabling environment (capacities, assessments, seed funding) and find practical means to encourage a greater private sector investment in carbon sequestration and land care. The Forum Working Group 3 calls on the CDM, and national and international organizations to effectively transform the market, reduce risks, reduce transaction costs, and maximize the multiple benefits from carbon sequestration.

3) That an international high-level roundtable bringing together business leaders and policy-makers from around the world should be convened in order to raise awareness on the multiple benefits of land restoration for poverty alleviation, ecosystem health and resilience.

Working Group 3 proposes the following plan of action:

1) Reduction of transaction costs through a 4-step process: (i) identify the existing costs and barriers in existing project cycles with emphasis on case studies; (ii) negotiate specific targets for the reduction of transaction costs; (iii) propose and negotiate steps with local and international agencies to reduce transaction costs; and (iv) require local and international agencies to report on their performance to reduce transaction costs.

2) Standardize objective-based methodologies for monitoring and verification.

3) Develop a portfolio of pilot projects to test and assess the bundling, risk management tools and lessons learned (including the testing of a combination of goals and projects).

4) Promote voluntary certification systems such as Climate, Community and Biodiversity Alliance (CCBA) standards as risk management approaches to address social and environmental safeguards for land restoration.

5) Engage the insurance sector in terrestrial carbon financing.

6) Strengthen capacity-building programmes, including through the establishment of a clearing-house mechanism, involving both governmental and non-governmental organizations.

7) Explore the possibility for a global institution to set up a flexible facility to work as a mediator between the buyers and the sellers in order to reduce transaction costs, manage risks and ensure multiple benefits for bio-carbon and land restoration projects.

8) Develop a certification system for calculating a premium for land restoration projects.

Working Group 4: Knowledge Management

Co-Chairs: David Niemeijer, Niemeijer Consul, and Mary Seely, Desert Research Foundation of Namibia
Rapporteur: Graham von Maltitz, CSIR Natural Resources and the Environment
Assistant to the Rapporteur: Karen Pálsdóttir, University of Iceland

Introduction

The aim of Working Group 4 was to analyze how knowledge management can lead to a more thorough and systematic understanding of the connections between soils, climate and society. Working Group 4 further discussed how knowledge management can lead to improved responses to the related challenges emerging from these connections.

Knowledge Management involves managing the process of creation, accumulation and application of knowledge across the scientific, policy and land user communities which deal with land degradation and climate change. This involves the creation of new knowledge (innovation) as well as the transfer of existing knowledge. Knowledge transfer is important for making explicit the often tacit, subconscious or individual knowledge that exists among local stakeholders, project staff and management, international and government agencies, non-governmental organizations (NGOs), and the scientific community. Though knowledge exists, it is often poorly captured and fails to bridge the gap between the different user groups and communities. Knowledge transfer requires capacity-building and the formation of cross-cutting ‘knowledge networks’ that extend beyond specific sectors, communities and other traditional divisions of society.

During its discussions, Working Group 4 focused on the following three areas: (i) needs and responsibilities in knowledge management; (ii) lessons learned in knowledge management, including successes and failures; and, (iii) capacity-building and knowledge sharing as a means for meeting the challenges of knowledge management. Working Group 4 brought together key conclusions, identifying key knowledge management issues and recommendations on how to address them, and a proposed plan of action, including suggestions on a timeframe and a means for implementing these actions (see Key Recommendations and Plan of Action).

Summary Report

Sustainable Land Management (SLM) is a relatively new field that encompasses many very different sectors, such as soil, climate and their related societal links. Integration among these fields is important for capacity development; however, bridging these fields poses unique challenges as each discipline has its own language and understanding of issues.

a) Needs and responsibilities in knowledge management

Working Group 4 came to the following conclusions regarding the needs and responsibilities in knowledge management:

- Knowledge management is key to bridging the gap between different SLM issues and to overcoming the disparity between the data and information collected or made available and the actual data and information requirements.
- Knowledge management is important in the filtering and organization of the often overwhelming amount of information available, including fragmented information storage, poor organization, and limited accessibility. Potential language barriers need to be recognized.
- Knowledge management needs may vary from situation to situation, and different stakeholders may have multiple and different needs and responsibilities in the creation and transfer of knowledge. Assessment of users should be done in order to properly identify the different stakeholders, how they access knowledge, how they define ‘knowledge’ and what their knowledge needs are. Mechanisms are needed for integration over a multitude of scales, from local land users through to global policy-makers, to ensure that the appropriate knowledge is available to all users.
- The varying knowledge needs of land users should be particularly recognized as they have an important role to play in conserving local knowledge. Land users should be recognized for their intellectual inputs, and can act as custodians of this knowledge. Extension officers, NGOs and other users and disseminators of information should also be included.
- Scientists have a large responsibility in knowledge management. Scientists are responsible for acquiring and consolidating information, monitoring changes in the environment and society, and supporting the community and stakeholders in dealing with these issues. Scientists have a responsibility to make their knowledge available in suitable formats at both the policy and land user levels, including transmitting insights from the land users to other stakeholders.
- Policy-makers also have a large responsibility in knowledge management; they are responsible for making value judgments based on the information provided by scientists in order to help land users.

b) Lessons learned: successes and failures in knowledge management

In its analysis of successes and failures in knowledge management, Working Group 4 identified two key challenges: (i) lack of support for data generation, including non-collection of data and loss of expertise for collecting the data; and, (ii) lack of adequate mechanisms to use the generated data and information in effective ways.

Table 1. Overview of the key knowledge management issues discussed in Working Group 4 as they relate to lessons learned. The table shows the contents of the index cards that both guided the discussion and came out of it; central aspects and possible solutions were listed, as well as how and who should address the issues.

Issue	Aspects/Solutions	How/Who?
Funding		• Better share existing funding
Capacity-building as a way to access/gain information	• Instruments and techniques • Capacity to evaluate existing data	• Appropriate national institutions
Knowledge base, wiki or WOCAT* for capacity-building	• Assessment of existing knowledge bases in order to avoid duplication of efforts and "re-inventing the wheel"	• WOCAT • GEF project KM:Land
Methodological harmonization (not solidification)	• Aligning methodologies across time and institutions	• UNEP Early Warning Assessment Division • FAO
Information synthesis	• Mechanism for synthesis of information into knowledge • Synthesis for nexus of soil and climate change (MEAs) • Identify and fill gaps • Assessments using "new" data • Follow-up for assessment procedures • Feedback to introduce new data to assessments	• UNEP GEO
Information "translation"	• Scientists must translate information for policy-makers and land users • Policy-makers have a responsibility to communicate information to land users • Translate information (assessments) into an accessible language for land users • Development of an ethics code	• Appropriate national institutions • Scientific practitioners and NGOs
Production and access to data	• Scientists have a responsibility to widely communicate data and information • Land users are custodians of local knowledge • Primary (new) data needed • Conduct workshops for data collection • Establish geo-referenced sites • Funding for consistent services • Fast-track accreditation of key data • NAPs, SRAPs	• National institutions with international support • International support for synthesis and coordination, e.g. FAO to ISRIC • FAO provides funding to make data available
Data Index	• Access to information • Exposure of existing data • Avoid duplication	• ICSU • (information from international programmes – description) • World data centres • FAO data processing

**Please see acronyms list for explanation of acronyms in this table.*

The following points provide more details on the issues discussed during this session:

- Key data sets need to be refreshed regularly in order to make up-to-date primary data available. New kinds of data may need to be collected or existing survey instruments may need to be amended. A strategic framework for data collection needs to be developed. The international community must recognize the importance of ground data and not rely on models and remote sensing alone.
- Capacity-building needs to be strengthened for those who want to access and understand existing data, and methods developed for data sharing between different users. A central database which is openly accessible and available needs to be developed and made widely known to potential users.
- Data needs to be presented in a manner and language that is coherent and accessible by different users. Scientists may need the support of communication experts in order to achieve this successfully.
- A mechanism is needed to synthesize the existing information available, to identify information and knowledge gaps, and to draw links between soil, society, climate and water. Furthermore, syntheses should adopt interdisciplinary and trans-disciplinary approaches, and scientists and policy-makers should consider producing syntheses jointly.
- Current synthesizing assessments need to include a follow-up component which allows for follow-up actions to be taken on the identified information and knowledge gaps.

- Currently, assessments based on peer-reviewed data are a cumbersome and lengthy process. A fast-track accreditation system is needed in order to incorporate new data and information in a more efficient manner.
- Projects and their corresponding budgets need to include a knowledge management component in order to ensure that the information that has been collected is well-organized, available and accessible to other users and future projects.
- As data generation is the responsibility of individual countries, financial and technical support should be provided to assist them in carrying out these tasks.
- Individual monitoring programmes need to be consolidated in order to share the responsibility and work for on-the-ground data collection.

c) Building capacity and sharing knowledge

Working Group 4 discussed and identified different approaches and tools for building capacity and sharing knowledge.

Table 2. Overview of key capacity-building approaches and tools discussed. The table shows the contents of the index cards used to guide the discussion, with approaches to capacity-building and knowledge-sharing listed, as well as the central aspects and key players involved in these approaches.

Approach	**Aspects**	**Who?**
Conferences, workshops	• Actionable items • Assign tasks	
Networks	• Benefits of participation • Participants - who? • Incentives to participate • E-learning • Co-learning • Incentives to participate • Two-way interaction	• Scientific community and international institutions
Training programmes	• Structured • Principles of problem-solving • Embedding informal system • Academic component • Negotiation techniques	• Agencies, businesses, industries
Formal academic courses, from primary to university (ILM*)	• Aligning methodologies across time and institutions	• Academic institutions
Farmer-to-farmer, or South-to-South data sharing	• Co-learning • Two-way interaction	• Projects, institutions
Publications	• Manuals, reports, scientific publications • Policy briefs	
Internships	• Formalized?	• UNU • National Institutions NGOs, agencies • Businesses
Dialogue on capacity-building	• Radio programmes	

**Please see acronyms list for explanation of acronyms in this table. N.B. There was also some discussion on capacity-building for land users; however, as the index cards were not sufficiently worked on, they have been omitted from Table 2.*

Additionally, Working Group 4 discussed the following points:

- An ethical code for research should be developed in order to streamline the responsibility for returning knowledge and information to the country and stakeholders; national institutions should be involved in translating such research results in forms useful to national and local stakeholders. Capacity-building and/or funding may be required in those countries where these are lacking.
- Capacity-building should include literacy training in order to address the challenge of including land users who are key players in sustainable land management.
- Mixing local and scientific knowledge through farmer field schools is a successful example of delivering capacity-building to farmers. Furthermore, training courses, such as the 6-month land restoration training course organized between the Agricultural University of Iceland and the Soil Conservation Service of Iceland have been successful in providing training to land users from developing countries through sharing experiences of land degradation issues and efforts made to rehabilitate the land, and provide an example of collaboration between a scientific and implementing agency.
- It is essential to gain the support of the multi-national agri-business for outreach training programmes, both in terms of funding and development. Training programmes should focus on key issues, and also include negotiating techniques for policy-makers from local to international levels.

- Non-traditional land users, such as recreational users of the land and engineers involved in the development of infrastructure, need to be taken into account. Raising awareness among these types of users is an important aspect in capacity-building.

Key Recommendations and Plan of Action

Working Group 4 agreed that in order to enable better land use decision-making, primary data must be augmented, maintained and improved. This requires ongoing financial and technical support to mandated national, regional and international institutions. In this process, it is important that methodologies for assessment of land degradation from the perspective of climate change, desertification and other major global processes are harmonized across organizations and updated as needed. A fast-track mechanism needs to be developed for incorporating new data into review assessments that are intended to synthesize existing information. To ensure wide access, data sets collected at any level need to be centrally catalogued.

Knowledge management should become a fundamental component in all projects funded by the Global Environment Facility (GEF) and other major donors. Scientists and scientific institutions have the responsibility to make information and knowledge available for land users and decision-makers at all levels. The World Business Council for Sustainable Development (WBCSD) and the Global Mechanism (GM) of the United Nations Convention to Combat Desertification (UNCCD) were encouraged to devise an action plan for the greater involvement of businesses in supporting sustainable land management and related capacity-building. The World Overview of Conservation Approaches and Technologies (WOCAT) and the GEF-funded medium-sized project Ensuring Impacts from Sustainable Land Management (KM:Land) should bring together networks to establish a knowledgebase that makes lessons learned accessible and facilitates capacity-building.

Table 3 summarizes the key issues in knowledge management, recommendations for improvement, and the plan of action identified by Working Group 4.

Table 3. Call-To-Action: Key issues in knowledge management, recommendations, and a proposed action plan.

What are the issues?	Recommendations on how to deal with the issue	Action plan*	How to implement and when?*
Current assessments provide essential knowledge synthesis. However, they are often based on old, outdated data and information which leads to ineffective or counter-productive decisions and policies. The use of outdated data and information is caused by limited access to data and information and lack of funding for collecting primary data to expand and update outdated data sets.	More funding should be allocated to the collection of primary data to update, expand and maintain essential data sets. New and existing data should be readily accessible through a centrally-maintained data index that provides an overview of all available international, regional, national and local datasets. Methodologies should be harmonized across institutions and time, while remaining open to new innovations. There should be a fast track accreditation or peer review process to allow the timely incorporation of new data and information into assessments and other syntheses.	To achieve these objectives, ongoing financial and technical support is needed for national institutes that are involved in data and information collection and the ICSU and associated world data centers as well as the FAO and UNEP-WCMC, who are involved in data and information warehousing and dissemination. Other organizations that can also contribute may be identified UNEP's DEWA should take responsibility to harmonize methodologies with support from FAO. UNEP and IPCC should implement fast track accreditation for new data and information. Data and information management should be a fundamental component in all GEF-funded projects.	This agenda needs to be pushed within FAO and UNEP before the end of the year. The STAP should provide guidance to GEF secretariat to include KM as a fundamental component in projects. It should be recommended that UNEP create a GEO report on land degradation and climate change.
Because funding for environment is limited and businesses have a lot of management experience and capacity, they can make a valuable contribution in improving the world's environment. Businesses have strong vested interests in SLM* (seed industries, fertilizer industry, etc.).	It is important to involve businesses in sponsoring and supporting capacity-building and raising awareness of environmental issues and in contributing to solutions.	WBCSD should encourage investments from their members for capacity-building and raising awareness. It should also work with GM to devise an action plan to engage more businesses in supporting sustainable land management.	UNU-INWEH will contact WBCSD and ISRIC will contact GM to raise these issues before the end of the year.

There is a repetition of efforts and wasting of resources in capacity-building because it is hard to find and benefit from lessons learned from other organizations.	Establish a knowledgebase or wiki related to lessons learned in capacity-building, similar to what WOCAT does for agricultural practices.	WOCAT and KM:Land should play an important role in bringing together networks to establish a knowledge base on lessons learned in capacity-building	WOCAT and UNU-INWEH have already started this process. ISRIC and WOCAT will discuss this issue in October with SDC.
Scientific information is not sufficiently or expeditiously available or is not in a useable form for decision-makers and land users.	Scientists and scientific institutions have the responsibility to make their key findings available and accessible to stakeholders at all levels, from land users to policy-makers. Scientists involved with natural resource management have a particular responsibility to ensure that relevant information and knowledge is transmitted to the biodiversity, water and climate change conventions and international institutions.	Universities, research and policy institutes should seek innovative ways of presenting their findings to decision-makers and other stakeholders, including land users. This includes stimulating scientists to learn how to present their findings to a wider audience. Funding streams should be used to guide integrated policy-relevant outputs.	Working Group 4 supports the activities of the regional and international scientific organizations such as OSS, IUCN and CILSS that already have this mandate. UNU must continue its focus on bridging SLM, CC and BD by packaging scientific findings in a useful form for policy development and create a programme that bridges across these areas. UNU-INWEH will follow up with this before the end of the year. Participants of the Forum should initiate a debate within their own institutions on their role and responsibilities in disseminating key scientific findings to the wider community.

**Please see acronyms list for explanation of acronyms in this table. N.B. Institutions mentioned here were present at the Forum; other relevant institutions may be identified.*

Working Group 5: Capacity-building Approaches in Legislative and Policy Development Techniques

Chair: Prof. Rob Fowler, University of South Australia
Rapporteur: Dr. Bernard Vanheusen, Hasselt University
Assistant to the Rapporteur: Hrafnhildur Bragadóttir, University of Iceland

Introduction

The key objective of Working Group 5 was to discuss approaches and techniques used for capacity-building in legislative and policy development and how to improve the legal and policy frameworks for the conservation and protection of soil at the international and national levels.

The Working Group agreed to focus it discussions on strategic direction rather than fine detail, but that it would also be important to identify clear actions and responsible parties. The Group further decided to mainly focus its deliberations on: the question of the need for a separate international instrument on soils; possibilities for addressing soil management within the existing MEAs; and other means of further promoting legislative development at national and international levels.

Summary Report

a) The Relative Merits of “Soft Law” vs. “Hard Law” Instruments

Ian Hannam (Organizing Committee member for Working Group 5) described the history of proposals for a type of international instrument related to sustainable soil management. He emphasized that work carried out to develop national and international law guidelines on soils had been done at the request of, and in consultation with, the scientific community.

Noting the existence since early 1980s of a range of “soft law” instruments on soils, most of the participants supported the idea of a “hard law” instrument for the following reasons:

1) Developing countries and countries with economies in transition would be assisted in implementing measures in the absence of a suitable national law.
2) Guidelines would not afford the same status to the soil issue as would a legal instrument.
3) A hard law instrument would better address transboundary issues than a soft law one.

It was suggested that implementation of an international instrument would require the involvement of bodies such as the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP). One participant from the USA expressed the preference for guidelines rather than a binding legal instrument.

b) Options for “Hard Law” Approaches

The various options related to using the “hard-law approach” were addressed with the following questions:

1) Is it preferable to rely on the existing Multilateral Environmental Agreements (MEAs) (United Nations Convention to Combat Desertification (UNCCD), United Nations Convention on Biological Diversity (UNCBD), United Nations Framework Convention on Climate Change (UNFCCC)), or to develop a separate legal instrument?
2) If a separate legal instrument is preferable, should a new convention or protocol to one of the existing MEAs be created?
3) If a protocol is favoured, which of the three MEAs should it be attached to?

The general content of a protocol/convention, and also the actions required to promote the development of such an instrument, were also considered by the Working Group.

Jaime Webbe of the CBD Secretariat provided an overview on the current activities on soil within the framework of the CBD. A work programme on agricultural biodiversity exists, but there is a lack of implementation and the programme has a low profile amongst the Convention parties. She suggested that these problems might be addressed by appointing a strong lead agency with an international status to head the programme and also to appoint an ad hoc Technical Experts Group. She also noted that the programme on agricultural biodiversity will soon undergo an in-depth review, which will provide an opportunity to consider these proposals.

Working Group 5 also addressed the possibilities for improving the focus of the CBD and the CCD on soils. Several participants suggested that it might be easier to draft a protocol to sit under the CBD rather than the CCD. In this context, participants also discussed the practicalities of how any new instrument would actually be implemented in light of existing capabilities and available resources. They also noted the need to consider the focus, purposes and intended effects of any international instrument, and considered the text of a draft protocol on the protection and sustainable use of soil prepared by the Specialist Group on Sustainable Use of Soils and Desertification of the International Union for Conservation of Nature’s (IUCN) Commission on Environmental Law (CEL).

Concerns were shared over the likelihood of any new instrument being created at this time, given "MEA fatigue", the financial aspect and the world's current focus on climate change. Yet, participants also noted limitations in both the CCD and the CBD with respect to the scope and coverage of the soils issues. Ultimately, Working Group 5 agreed overall on the need for some form of international instrument.

Participants explored the issue of developing a "soil ethic", recognizing a need to better integrate a concern for soil values and ethics into international declarations on global ethics. In this regard, they explored possibilities for linking the Earth Charter to a soil ethic.

Finally, Working Group 5 held a joint meeting with Working Group 2 on Soil Management for Promoting Synergies in the Implementation of the Three UN Rio Conventions. The Working Groups shared the results of their respective discussions, and exchanged views on these results, including on the suggestion made by Working Group 2 for national guidelines to be implemented within the CCD with respect to soils.

Key Recommendations and Plan of Action

On the basis of the results of their discussions, Working Group 5 drafted the following Recommendations and Plan of Action, specifically indicating: a) who should take action; b) when; and, c) the *modus operandi* to be used.

1) Soft Law vs. Hard Law Concerning Soils

Noting that soft law measures concerning soils have been in place for a considerable period but have not led to sufficient protection of soils against erosion, compaction, sealing, contamination and other soil threats, it is recommended that a binding international instrument relating to the protection and sustainable use of soils be developed.

a) Who: see Recommendation 2.
b) When: see Recommendation 2.
c) *Modus operandi*: see Recommendation 2.

2) A Binding International Instrument Concerning the Protection and Sustainable Use of Soils

Noting the limitations of both the CCD and CBD within their frameworks with respect to the scope and coverage for the sustainable use of soils, and also acknowledging the current reluctance of the Parties to both Conventions to consider any substantial revision to any part of their texts, the Working Group recommends that the IUCN, through its CEL Specialist Group on Sustainable Use of Soil and Desertification, and in consultation with the Commission's Ethics Specialist Group and the soil science community, progress the work on the Draft Protocol for the Protection and Sustainable Use of Soil pursuant to the Soil Resolutions of the IUCN World Conservation Congress, with the aim of advancing the process for the development of a binding international instrument.

a) Who: The IUCN, through its CEL Specialist Group on Sustainable Use of Soil and Desertification and in consultation with the Commission's Ethics Specialist Group and the soil science community.
b) When: This complete work is currently in progress in time for delivery to the 8^{th} IUCN World Conservation Congress (Barcelona, October 2008).
c) *Modus operandi*: Meetings of the Specialist Group and referral of proposals to the IUCN CEL Steering Committee.

3) Soil Ethics

Recognizing the need to better integrate a concern for soil values and ethics into international declarations of global ethics, and in particular into the Earth Charter, and the potential for strengthening soil conservation by elaborating the implications of these agreements for soil ethics, it is recommended that the Earth Charter Council, in partnership with the Ethics and Soils Specialist Groups of the IUCN CEL and other interested parties such as European Society for Soil Conservation (ESSC), World Association of Soil and Water Conservation (WASWC), International Union of Soil Sciences (IUSS), prepare an interpretive statement concerning the ways in which soil ethics can be incorporated into the Earth Charter Initiative.

a) Who: The Earth Charter Council, in partnership with the Ethics and Soils Specialist Groups of the IUCN CEL and other interested parties, such as European Society for Soil Conservation, World Association of Soil and Water Conservation, International Union of Soil Sciences.
b) When: December 2008, following the IUCN World Conservation Congress (Barcelona, October 2008).
c) *Modus operandi*: An initial consultation between Ron Engel, Co-Chair of the Earth Council, Razeena Waiget, and Co-Chairs of the CEL Ethics Specialist Group at the Chicago IUCN Biosphere Ethics Project Meeting, 10-15 September 2007. A communication would then be brought to the Earth Council by the Co-Chair and to the Soil Specialist Group to join in the formation of a drafting committee to implement this resolution.

4) UNCBD

Noting the UNCBD's approved work programme on agricultural biodiversity and the current lack of implementation of this programme, it is recommended that:

- a lead international agency be appointed by the Conference of the Parties (COP) to take responsibility for the work programme with respect to soil biodiversity and soil protection; and
- the COP, following the conduct of the forthcoming in-depth review of the work programme on agricultural biodiversity, appoint an ad hoc Technical Experts Group to provide technical expertise in support of the work programme.

a) Who: CBD COP.
b) When: Next meeting of the COP (Bonn, May 2008).
c) *Modus operandi*: IUCN Environmental Law Programme to request the CBD Secretariat to place these proposals on the agenda for the next COP.

5) UNCCD

This Working Group recommends that the IUCN CEL Specialist Group on Sustainable Use of Soils and Desertification develop guidelines to assist national governments to implement their responsibilities under the UNCCD in relation to the protection and sustainable use of soils.

a) Who: The IUCN CEL Specialist Group on Sustainable Use of Soils and Desertification.
b) When: Within the next twelve months.
c) *Modus operandi*: An initial meeting of the Specialist Group with representatives of the CCD Secretariat in Bonn within the next three months to set the framework for the development of the guidelines.

6) Guidelines for National Legislation

Noting that there is a need to develop new or improved legislation concerning the protection and sustainable use of soils in many countries, Working Group 5 recommends that guidelines for national legislation be prepared by the IUCN CEL, through its Specialist Group on Sustainable Use of Soils and Desertification in consultation with other relevant institutions such as the United Nations Environment Programme (UNEP).

a) Who: The IUCN CEL through its Specialist Group on Sustainable Use of Soils and Desertification.
b) When: By December 2008.
c) *Modus operandi*: To expand and further develop the existing draft of optional frameworks for national soil legislation reform in consultation with other relevant institutions such as UNEP.

7) Soil Contamination

Noting that the contamination of soils, both by anthropogenic and naturally occurring sources, poses a significant threat to human health, particularly in relation to the provision of safe drinking water, and noting that there is a significant lack of legislation to address this problem in many developing countries, this Working Group recommends that the IUCN CEL Specialist Group on Sustainable Use of Soils and Desertification develops guidelines for national legislation concerning the treatment of contaminated soils.

a) Who: The IUCN CEL Specialist Group on Sustainable Use of Soils and Desertification.
b) When: By December 2008.
c) *Modus operandi*: Meetings of the Specialist Group and consultation with relevant international soil science institutions.

Programme for Action

Programme for Action

Successful implementation of efforts to prevent, mitigate and adapt to environmental and social changes begins with the stewardship of the soil by and for the users of the land.

Stewardship of the soil results in a variety of benefits, including:

- ✓ Conservation of the soil resource and of the ecosystem services that depend upon it
- ✓ Improved food security and fibre productivity for human well-being and development
- ✓ Increased water storage capacity and flood prevention and water supply
- ✓ Increased capture and retention of carbon and other greenhouse gases to mitigate global climate change

Experiences of soil stewardship and restoration efforts in communities around the world are diverse and location-specific. Participants at the International Forum on Soils, Society & Global Change held in Selfoss, Iceland to celebrate one-hundred years of soil conservation and vegetation restoration in the country brought together experiences from around the world to build a common understanding of the vital importance of soil and soil stewardship. We have resolved on the following actions.

Recognizing that there are many institutions and other partners already engaged in the field which are not mentioned below, we invite other interests to engage in the Programme for Action.

1. Promoting Soil Stewardship and Land Care

A set of guiding principles on soil stewardship and land care is being drafted by an informal working group emerging from the Forum. These will be used as the basis for raising awareness, education and training activities, preferably through joint initiatives across the three UN Conventions on Biodiversity (UNCBD), Combating Desertification (UNCCD) and Climate Change (UNFCCC). The working group will also collate practical sources of knowledge and lessons learned from experiences into a knowledge base to assist land care practitioners around the world. The knowledge base will include successful examples of land literacy projects aimed at assisting young people to ‘read the land’ and information on the emerging issue of carbon sequestration benefits from land care initiatives. An International Year of Land Care should be considered. A group of Forum participants has been convened to explore these possibilities with interested governments. An interpretative statement to the Earth Charter to promote soil ethic will be prepared by relevant interested parties.

2. Operationalizing Synergies Between the Conventions Through Joint Implementation of Soil Stewardship Initiatives

A joint mechanism amongst the Conventions is to be initiated by the UNCCD to achieve synergies in the implementation of the Multilateral Environmental Agreements (MEAs). These will begin with a request to the Intergovernmental Panel on Climate Change (IPPC) to develop a Special Report on Land Degradation and Climate Change (as done previously for the UNCBD with respect to biodiversity). This document, together with other existing documents addressing synergies in the subject matters of the three Conventions, will be assessed by an ad hoc group of experts under the Joint Liaison Group (JLG).

Based on this assessment, the group will compile guidelines for joint implementation of the three Conventions, targeting Focal Points and donors of these Conventions. A second avenue of achieving synergies in implementation will be a certification mechanism independently developed by each Convention for assessing the added benefit of actions under one Convention to the subject matters of the other Conventions. The CBD will be requested to review its work on agricultural biodiversity, to create an advisory body, and to identify a lead agency for its implementation.

3. Enabling Knowledge Management to Inform Better Decision-making

To enable better land-use decision-making, primary data must be augmented, maintained and improved. This requires ongoing financial and technical support to mandated national, regional and international institutions. In this process, it is important that methodologies for assessment of land degradation from the perspective of climate change, desertification and other major global processes be harmonized across organizations and updated as needed. A fast-tracking mechanism has to be developed for incorporation of new data into assessments. To ensure access, datasets collected at any level need to be centrally catalogued. Knowledge management should become a fundamental component in all projects funded by the Global Environment Facility (GEF) and other major donors. Scientists and scientific institutions have the responsibility to make information and knowledge available for land users and decision-makers at all levels. We encourage the World Business Council for Sustainable Development (WBCSD) and the Global Mechanism (GM) of the UNCCD to devise an action plan for the greater involvement of businesses in supporting sustainable land management and related capacity-building. The World Overview of Conservation Approaches and Technologies (WOCAT) and the GEF-funded Medium Sized Project on Ensuring Impacts from Sustainable Land Management (Knowledge Management of the Land or “KM:Land”) should bring together networks to establish a knowledge base that makes lessons learned accessible and facilitates capacity-building.

4. Improving Legislation and Policy Frameworks Through Capacity-building

The International Union for Conservation of Nature's (IUCN) Commission on Environmental Law (CEL) Specialist Group on Sustainable Use of Soils and Desertification will develop guidelines for national governments to strengthen the capacity of their legal frameworks for implementing the UNCCD and is developing proposals for new or improved soils legislation, including a provision with respect to soil contamination. The Forum recognized that the Specialist Group has also been engaged for some time in discussions on the formulation of a new, binding, international instrument concerning the protection and sustainable use of soils. This work will be progressed by the Commission, in consultation with the soil science community, with the aim of strengthening the current legal, policy, ethical and institutional frameworks at both national and international levels. Enhanced human capacity and knowledge management for the implementation of laws and policies will be promoted through the actions proposed by Working Group 5 of this Forum.

5. Galvanizing Support from the Business Community and Decision-makers for Soil Stewardship Including Recognition of Carbon Sequestration Benefits

At least one quarter of the excess CO_2 in the atmosphere has come from land use change in the last century. The challenge is to put this carbon back into the soils, where it is needed. In order to do this, a better understanding of processes, practices, measurement and monitoring of carbon sequestration in terrestrial ecosystems is needed. The global potential of 1-2 billion tonnes of carbon sequestration by restoration of degraded ecosystems is estimated to be US$ 30 billion/year at present market values (September 2007).

Priority investment by donors and the private sector would strengthen capacity, policy and assessment for carbon sequestration. Working Group 3 of this Forum calls on the Clean Development Mechanism (CDM) and national and international organizations to transform market mechanisms, reduce risks, reduce transaction costs, maximize the multiple economic and social benefits from carbon sequestration in soils, and maximize the synergies between restoring ecosystem health and resilience, and mitigating climate change. The benefits of land restoration will depend on strengthening human resource and technical capacity of local institutions. With these actions, it is possible to expand the carbon markets – state-mandated, CDM and voluntary – and to maximize benefits to local land users.

A high-level round table of scientists, business leaders and policy-makers is called for to put this issue in the mainstream of development policy.

DON'T FORGET THE SOIL!

Forum Programme

FRIDAY 31ST AUGUST 2007

Opening Session
Chair: Sveinn Runólfsson, Soil Conservation Service of Iceland

9:00 - 9:15 Opening Address: Minister of Fisheries and Agriculture of Iceland
Mr. Einar K. Gudfinnsson

9:15 - 10:00 Addresses from International Organizations
- Food and Agriculture Organization of the United Nations, *Parviz Koohafkan*
- United Nations Convention to Combat Desertification, *Goodspeed Kopolo*
- Convention on Biological Diversity, *Jaime Webbe*
- United Nations Environment Programme, *Gemma Shepherd*
- European Commission, Joint Research Centre, *Luca Montanarella*

10:00 - 10:10 Forum Introduction, Context and Objectives
Andrés Arnalds, Chair of Forum Organizing Committee, Soil Conservation Service of Iceland

10:10 - 10:30 Introduction to Forum Working Groups: Themes and Objectives

10:30 - 11:00 Coffee Break

Session 1: Setting the Stage: Soils, Society and Global Change – The Global Perspectives
Chair: Roger Crofts, IUCN World Commission on Protected Areas & Commission on Ecosystem Management

11:00 - 11:20 Soils and the Living Earth
Ólafur Arnalds, Agricultural University of Iceland

11:20 - 11:40 Global Land Degradation: State, Risks and Prospects under Global Change
Uriel Safriel, Hebrew University of Jerusalem

11:40 - 12:00 The Global Social and Ethical Context of Sustainable Land Management
Maryam Niamir-Fuller, United Nations Development Programme

12:00 - 12:20 Questions and Discussion

12:30 - 13:30 Lunch Break

Session 1: Setting the Stage: Soils, Society and Global Change – The Regional and Local Perspectives
Chair: Roger Crofts, IUCN World Commission on Protected Areas & Commission on Ecosystem Management

13:30 - 13:45 Land Degradation/Desertification, Society and Global Change in Latin America
Elena María Abraham, Instituto Argentino de Investigaciones de las Zonas Áridas

13:45 - 14:00 Agriculture – a Poverty Trap in Drylands?
Sem Shikongo, Directorate of Environmental Affairs, Ministry of Environment and Tourism (Namibia)

14:00 - 14:15 Iceland and the Global Picture
Andrés Arnalds, Soil Conservation Service of Iceland

14:15 - 14:30 Panel Discussion: Questions and Discussion

14:30 - 14:35 Introduction to the drafted Selfoss Statement
Roger Crofts, IUCN World Commission on Protected Areas & Commission on Ecosystem Management

14:35 - 14:40 Introduction to the Field Seminars
Gudmundur Halldórsson, Soil Conservation Service of Iceland

14:55 Field Seminar (Hólaskógur – Hekluskógar – Gunnarsholt) followed by dinner at SCS Headquarters in Gunnarsholt

<u>SATURDAY 1ST SEPTEMBER 2007</u>

Session 2: Healthy Soils – Supporting Food Security, Water Provision, Poverty Reduction and Biodiversity
Chair: Magnús Jóhannesson, Ministry for the Environment (Iceland)

8:30 - 8:50	Agriculture, Land and Global Changes *Parviz Koohafkan, Food and Agricultural Organization of the United Nations*
8:50 - 9:10	Land Degradation and Sustainable Management of Water Resources *Zafar Adeel, United Nations University – International Network on Water, Environment and Health*
9:10 - 9:30	The Role of Ecological Restoration and Sustainable Land Management for Biodiversity *Ása L. Aradóttir, Agricultural University of Iceland*
9:30 - 9:50	Capacity Building for Developing National Legal Policy Frameworks for Soil Conservation and Protection *Ian Hannam, University of New England*
9:50 - 10:20	*Coffee Break*
10:20 - 10:40	A Global Systems Approach for Healthy Soils *Michael Stocking, University of East Anglia*
10:40 - 11:00	The Economics of Ecosystem Services *Mélanie Requier-Desjardins, The Sahara and Sahel Observatory*
11:00 - 11:30	Questions and Discussion
11:45 - 13:00	*Lunch Break*

Session 3: Mitigating Climate Change through Restoration of Degraded Land
Chair: Brynhildur Davidsdóttir, University of Iceland

13:00 - 13:20	Mitigating Climate Change through Combating Soil Degradation and Desertification *Rattan Lal, The Ohio State University*
13:20 - 13:40	Carbon Finance and MDGs *Anna Tengberg, United Nations Development Programme*
13:40 - 14:00	Harnessing Carbon Finance for Land Restoration – Can It Be Done and Will It Work? *Richard Tipper, Edinburgh Centre for Carbon Management*
14:00 - 14:20	Opportunities for Climate Change Mitigation in Agriculture: A Semi-Quantitative Assessment of Costs and Reduction Levels *Louis Verchot, International Council for Research in Agroforestry*
14:20 - 14:40	Can Iceland Become a Carbon Neutral Country by Reducing Emissions and Restoring Degraded Land? *Anna María Ágústsdóttir, Soil Conservation Service of Iceland*
14:40 - 15:10	Questions and Discussion
15:10 - 15:40	*Coffee Break*
15:40 - 17:30	Parallel Working Group Sessions
19:00	Dinner at Hotel Selfoss
20:00 – 22:00	Open Discussion on the Icelandic Land Restoration Training Programme

SUNDAY 2[ND] SEPTEMBER 2007

Session 4: Creating an Enabling Environment
Chair: Sizwe Mkhize, National Department of Agriculture (South Africa)

8:30 - 8:50	Our Covenant with Earth: the Contribution of Soil Ethics to Our Planetary Future *J. Ronald Engel, Center for Humans and Nature*
8:50 - 9:10	Learning and Knowing Our Way to Better Land Care *Andrew Campbell, Triple Helix Consulting*
9:10 - 9:30	Engaging Stakeholders in Integrated Natural Resource Management: Experiences and Lessons from Landcare *Delia Catacutan, World Agroforestry Centre*
9:30 - 9:40	Reading the Landscape *Gunnar Bjarnason, Agricultural Council of Faroe Islands*
9:40 - 10:10	*Coffee Break*
10:10 - 10:30	Incentives and Disincentives: A Systematic Approach *Paul Martin, Australian Centre for Agriculture and Law, University of New England*
10:30 - 10:50	Global Gender Issues and Sustainable Land Management *Mirey Atallah, United Nations Development Programme*
10:50 - 11:20	Questions and Discussion
11:30 - 12:30	*Lunch*
12:30 - 14:00	Parallel Working Group Sessions
14:00 - 14:15	*Break*
14:15 - 15:30	Parallel Working Group Sessions
15:30 - 15:50	*Coffee Break*
16:00 – 19:00	Field Seminar (Thorlákshöfn – Hengill – Ölkelduháls – Gígahnjúkar – Skarðsmýrarfjall) *Jointly Organized by the Reykjavík Energy and the Soil Conservation Service of Iceland*
19:00	Light Dinner at the Hellisheidi Geothermal Power Plant (Reykjavík Energy)

MONDAY 3[RD] SEPTEMBER 2007

8:30 - 10:00	Parallel Working Group Sessions
10:00 - 10:30	*Coffee Break*
10:30 - 12:00	Parallel Working Group Sessions
12:00 - 12:30	Parallel Working Group Sessions: Wrap Up
12:30 - 13:30	*Lunch*

Session 5: Working Group Reports and Discussion
Chair: Anton Imeson, Amsterdam University

13:30 - 14:20 Reports by Working Group Chairs

14:20 - 15:30 Discussion on Working Group Reports

15:30 - 16:30 Coffee Break

Session 6: Forum Conclusions, Recommendations and Discussion
Chair: Ingibjörg S. Jónsdóttir, Icelandic Land Restoration Training Programme

16:30 - 16:50 Forum Conclusions and Recommendations

16:50 - 17:30 Discussion on Forum Conclusions and Recommendations

18:30 Forum Dinner at Hotel Selfoss

TUESDAY 4TH SEPTEMBER 2007

Closing Session: Centennial Celebratory Event
Chairs: Kristín Ingólfsdóttir, University of Iceland and Ágúst Sigurdsson, Agricultural University of Iceland

10:00 -10:20 Celebratory Speech
His Excellency the President of Iceland, Mr. Ólafur Ragnar Grímsson

10:20 - 10:35 Iceland's Century of Conserving and Restoring Soil and Vegetation
Sveinn Runólfsson, Soil Conservation Service of Iceland

10:35 - 10:45 Soil Conservation in Iceland: Celebrating a Century and Looking Forward
Roger Crofts, IUCN World Commission on Protected Areas & Commission on Ecosystem Management

10:45 - 11:00 Addresses from Icelandic Organizations
- The Iceland Forest Service, *Thröstur Eysteinsson*
- The Icelandic Farmers Association, *Sigurgeir Thorgeirsson*

11:00 -11:15 Forum Rapporteur's Overview – Results from the Forum
Roger Crofts, IUCN World Commission on Protected Areas & Commission on Ecosystem Management

11:15 -11:45 Addresses by International Organizations
- United Nations Development Programme, *Olav Kjørven*
- United Nations Framework Convention on Climate Change, *Halldór Thorgeirsson*
- United Nations University, *Zafar Adeel*
- Clinton Foundation, *Jan Hartke*

11:45 - 12:00 Common Ground for 21st Century Conservation
Dana York, Associate Chief, United States Department of Agriculture – Natural Resources Conservation Service

12:00 - 12:20 Honorary Speech
Rajendra K. Pachauri, Director-General of TERI and Chairman of the Intergovernmental Panel on Climate Change

12:20 – 12:30 Closing Remarks
Andrés Arnalds, Chair of Forum Organizing Committee, Soil Conservation Service of Iceland

12:30 Close of the Forum

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Appendix 1: List of Acronyms

AEZ	Agro-Ecological Zones
AGDP	Agricultural Gross Domestic Product
ALMS	Australian Landcare Management System
AR	Afforestation-Reforestation
AUI	Agricultural University of Iceland
BD	Biodiversity
CA	Conservation Agriculture
CBNRM	Community-based Natural Resources Management
CC	Climate Change
CCBS	Community, Carbon and Biodiversity Standard
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanism
CEL	Commission on Environmental Law
CER	Carbon Emission Reductions
CFC	Chlorofluorocarbon
CFI	Federal Investment Council
CILSS	Comité Permanent Inter-Etats de Lutte Contre la Sécheresse au Sahel
COMLAND	Commission on Land Degradation & Desertification
COP	Conference of Parties
CSD	Commission on Sustainable Development
CST	Committee on Science and Technology
DEWA	Division of Early Warning and Assessment
DPSIR	Driver, Pressure, State, Impact, Response
DRFN	Desert Research Foundation of Namibia
EC-JRC	European Commission – Joint Research Centre
ELP	Environmental Law Programme
ENCOFOR	Environment and community-based framework for designing afforestation, reforestation and revegetation projects in the CDM
ENSO	El Niño Southern Oscillation
EPWP	Expanded Public Works Programme
ERR	Economic Rate of Return
ESSC	European Society for Soil Conservation
EU	European Union
EU-SCAPE	European Union – Soil Conservation and Protection in Europe
FAO	Food and Agricultural Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEO	Global Environment Outlook
GHG	Greenhouse gas
GLADA	Global Land Degradation Assessment
GLASOD	Global Assessment of Human Induced Soil Degradation
GM	Global Mechanism of the United Nations Convention to Combat Desertification
GNI	Gross National Income
GO	Governmental Organization
GOE	Group of Experts
GTZ	German Technical Cooperation Agency (Gesellschaft für Technische Zusammenarbeit)
HCFC	Hydrochlorofluorocarbon
IADB	Inter-American Development Bank
IADIZA	Argentine Institute for Arid Lands Research (Instituto Argentino de Investigaciones de las Zonas Aridas)
IANIGLA	Argentine Institute for Snow, Ice and Environmental Sciences (Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICRAF	World Agroforestry Centre
ICSU	International Council for Science
IEM	Integrated Ecosystem Management
IFAD	International Fund for Agricultural Development
IFAP	International Federation of Agricultural Producers
IFDC	International Fertilizer Development Center
IIASA	International Institute of Applied Systems Analysis
IISD	International Institute for Sustainable Development
ILM	Integrated Land Management
INRM	Integrated Natural Resources Management
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control

ISRIC	World Soil Information (International Soil Reference and Information Centre)
IUCN	International Union for Conservation of Nature
JLG	Joint Liaison Group
KM	Knowledge Management
KM: Land	Knowledge Management: Land (GEF medium-sized project on Ensuring Impacts from Sustainable Land Management)
LADA	Land Degradation Assessment in Drylands
LaDyOt	Laboratorio de Desertificacion y Ordemanmineto Territorial
LCA	Land Care Association
LULUCF	Land Use, Land Use Change and Forestry
MA	Millennium Ecosystem Assessment
MEA	Multilateral Environmental Agreement
MDG	Millennium Development Goal
NAP	National Action Programmes
NGO	Non-governmental organization
NRM	Natural Resources Management
ODA	Official Development Assistance
OECD	Organisation for Economic Co-Operation and Development
OSS	The Sahara and Sahel Observatory (Observatoire du Sahara et du Sahel)
OSU	The Ohio State University
PDSI	Palmer Drought Severity Index
PES	Payment for Environmental Services
PRC-GEF	People's Republic of China – Global Environment Facility
SARD	Sustainable Agriculture and Rural Development
SCS	Soil Conservation Service of Iceland
SDC	Swiss Agency for Development and Cooperation
SLM	Sustainable Land Management
SLaM	Sustainable Land Management for Mitigating Land Degradation, Enhancing Agricultural Biodiversity and Reducing Poverty
SOTER	Soil Terrain Database
SRAP	Sub-Regional Action Programmes
STAP	Scientific and Technical Advisory Panel
SWC	Soil and Water Conservation
TERI	Tata Energy and Resources Institute
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNU	United Nations University
UNU-INWEH	United Nations University – International Network on Water, Environment and Health
UPYS	Pilot Unit of Production and Services
USAID	United States Agency for International Development
USDA-NRCS	United States Depart of Agriculture – Natural Resources Conservation Service
USEPA	United States Environmental Protection Agency
VER	Verified Emission Reductions
WAD	World Atlas of Desertification
WASWC	World Association of Soil and Water Conservation
WBCSD	World Business Council for Sustainable Development
WCMC	World Conservation Monitoring Centre
WFS	World Food Summit
WG	Working Group
WOCAT	World Overview of Conservation Approaches and Technologies

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Abstract
The International Forum on Soils, Society & Global Change was held from 31 August to 4 September 2007 in Selfoss, Iceland. The aim of the Forum was to explore the synergistic roles of soil conservation and vegetation restoration in meeting local, regional and global environmental and social challenges, and to propose recommendations and action plans for achieving these goals. The Forum was hosted by the Soil Conservation Service of Iceland, in partnership with Icelandic and international agencies, organizations and universities. It marked the centenary of organized soil conservation and land restoration in Iceland. With its extensive problems of land degradation and desertification, and its numerous success stories in halting severe soil erosion and in restoring damaged land, Iceland provided an excellent venue to discuss and evaluate the role of soils in sustaining society and environment. This book comprises the addresses and keynote papers given at the Forum and reports on the outcomes from plenary and working group discussions. The Rapporteur's overview outlines some of the main issues of the Forum, and finally, the book proposes a Programme for Action agreed to by the Forum participants.

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Soils, Society & Global Change

Proceedings of the International Forum Celebrating the Centenary of Conservation and Restoration of Soil and Vegetation in Iceland
31 August - 4 September 2007, Selfoss, Iceland

Edited by Harriet Bigas, Gudmundur Ingi Gudbrandsson,
Luca Montanarella and Andrés Arnalds

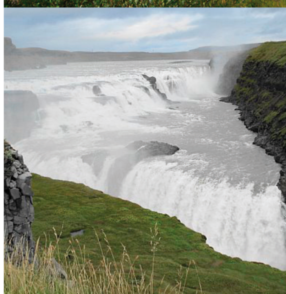
This book highlights how our ability to manage soils plays an important role in global challenges such as climate change, biodiversity reduction, food and water security, and economic and social progress. It explores policy and legal challenges, knowledge management issues, and the crucial role of soil in the successful implementation of the global environmental conventions. The book concludes with the Programme for Action which includes a number of proactive recommendations on how global policies can be improved to protect soil as a resource.

The context for this book is the 2007 centennial celebrations of organized conservation and restoration of soil and vegetation in Iceland. As Europe's northernmost nation, Iceland historically suffered acute land degradation problems and through a century of perseverance has now become a world leader in soil restoration research and techniques. A number of international partners and world-class experts on a variety of pertinent fields gathered in Selfoss, Iceland to join in an International Forum. This book outlines the groundbreaking ideas developed by these experts to address the global soil problems and innovative ways to address the combined challenges of soil, society and global change.







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