Sustainable Land Management and Its Relation to Climate Change

Michael Stocking
Vice-Chair, GEF-STAP
Professor, University of East Anglia, Norwich, UK

Two Sides of the Same Coin

Sustainable Land Management

Land degradation

UNCCD
Sustainable Land Management and Its Relation to Climate Change – Michael Stocking

A systems view of SLM

Three ways to achieve systems approach in SLM

- Find synergies with other focal areas
  - Biodiversity
  - Climate change (Intervention 1)
  - International waters
- Relate SLM to global development agendas (2):
  - Poverty alleviation
  - Food security
  - Livelihoods
- Identify practical interventions in:
  - Techniques and approaches (3)
  - Knowledge and research (4)
  - Strategies and policies (5)
  - Laws and institutions (6)
Key Principle – Synergy

“The interaction of two or more agents or forces so that their combined effect is greater than the sum of their individual effects.”

Global Synergy Database:
- most examples are about achieving additional benefits beyond the immediate purpose

To exploit the synergies ……

A systems approach is needed to:
- Harness benefits for development and environment
- Capture ‘feedback’ loops
- Avoid simplistic responses
- Mimic the real world
Ecosystem services

- **Provisioning**
  - Goods produced or provided by ecosystems

- **Regulating**
  - Benefits obtained from regulation of ecosystem processes

- **Cultural**
  - Non-material benefits from ecosystems

The MA Model – Feedback Loops in Global Change

Source: MA, 2004; Gisladottir & Stocking, 2005

CSD16, Learning Centre course, New York – May 2008
Sustainable Land Management and Its Relation to Climate Change – Michael Stocking

A simple impact matrix

<table>
<thead>
<tr>
<th></th>
<th>LD</th>
<th>CC</th>
<th>BD</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD</td>
<td>√√√</td>
<td></td>
<td>√√</td>
</tr>
<tr>
<td>CC</td>
<td>√</td>
<td>√√</td>
<td></td>
</tr>
<tr>
<td>BD</td>
<td>√√√</td>
<td>√</td>
<td>√√</td>
</tr>
</tbody>
</table>

Major and best-recognised linkages
Important positive (reinforcing) feedback loops

Example of land-based synergies

Mid-hills of W. Nepal:
• Water conservation
• Carbon fixed
• Nutrients retained & used
• Pressure off woodland

Pots near Landruk, W. Nepal

CSD16, Learning Centre course, New York – May 2008
Sustainable Land Management and Its Relation to Climate Change – Michael Stocking

Yams within an agroforestry system at Adwenso, southern Ghana

Sustainable Land Management

**Definition:** The use of renewable land resources (soils, water, plants, and animals) for production and services while protecting the long-term productive potential of these resources.

**Mandate:** To coexist with nature so that the productive, physiological, cultural and ecological functions of natural resources are maintained for the benefit of society.

**Challenge:** To harmonise the complementary but often conflicting goals of production and environmental protection.
LD is........ a worldwide problem

And society deals with it.....
How much does land degradation cost?

Monetary value of lost production about $65 billion annually, consisting of:

- $35 billion from rangeland, primarily in arid and semi-arid zones
- $12 billion from rainfed cropland, much of this under subsistence farming
- $17 billion from irrigated lands, through salinisation and groundwater pollution

How much Carbon goes with soil erosion?

Soil organic C pool is 40 – 100 t/ha
- = c. 5% total soil is org C in top 10 cm

- Organic C is selectively eroded [ER≥2]
- On well-managed soils, loss=0.4 tC/ha/yr
- On typical rainfed cropland, 2.5 tC/ha/yr
- On steep slopes, no conservation, 10tC/ha/yr
What and who is affected?

Land out of production because of land degradation – estimated at 5 to 7 million hectares a year
Proportion of earth’s land surface affected seriously - 33%
Population affected by serious degradation in drylands alone – estimated at 2.6 billion people in more than 100 countries

Linking SLM and CC

1. Agriculture’s ambivalent role
2. Opportunities in land use (LULUCF)
   - Soil management – soil biodiversity
   - Changing land use
   - Encouraging ‘agrodiversity’
   - Reducing emissions (REDD)
3. Carbon sequestration
1. Agriculture’s ambivalent role

- Agriculture contributes *directly* to CC via emissions of methane and nitrous oxides
- It contributes *indirectly* via demand for fertilizer, other chemicals and fuel
- Climate change, in turn, will change agricultural production dramatically
- Agriculture is *currently* a net contributor to climate change
2. Opportunities in land use (LULUCF)

“Activities in the LULUCF sector can provide a relatively cost-effective way of offsetting emissions, either by increasing the removals of greenhouse gases from the atmosphere (e.g. by planting trees or managing forests), or by reducing emissions (e.g. by curbing deforestation)”

“But greenhouse gases may be unintentionally released into the atmosphere if a sink is damaged or destroyed through a forest fire or disease.”

[Source: UNFCCC http://unfccc.int/methods_and_science/lulucf/items/3060.php]

Practical examples of SLM with benefits for CC

✓ Encouraging soil biodiversity
✓ Focus on ‘agrodiversity’
Soil Biodiversity: Provider of essential ecosystem goods and services

- Nutrient cycling
- Regulation of dynamics of soil organic matter
- Soil C sequestration and reduced GHG emissions
- Modification of soil physical structure and maintain water regimes
- Assistance to plant nutrient acquisition
- Enhancement of plant health...

Soil Biodiversity is vast….and largely uncharted

Soils may contain:
- several vertebrates and earthworms
- 20-30 species of mites
- 50-100 species of insects
- tens of species of nematodes
- hundreds of species of fungi
- thousands of species of bacteria
Soil biodiversity particularly important to poor farmers

The goods and services provided by diverse soil organisms and their interactions are of particular significance.

- Maintaining soil productivity free
- Reducing need for mineral fertilizers
- Increasing efficiency of use of inputs
- Making soil easier to manage
People, Land Management and Environmental Change (PLEC)

Agrodiversity - a good news story
Sustainable Land Management and Its Relation to Climate Change – Michael Stocking

**PLEC verified complex stories in complex landscapes**

- Upper-slope sediment, nutrient and water sources
- Rice paddies harvesting sediment
- Highly productive Kandy home gardens

**Agrodiversity link to livelihoods**

- Different farmers have different opportunities
- Sloping land affords different challenges
- Poorer farmers have steepest land, but often the greatest agrodiversity
Sustainable Land Management and Its Relation to Climate Change – Michael Stocking

Working with farmers

PLEC-Papua New Guinea

Field Indicators for SLM & agrodiversity

PLEC-Uganda
Soil indicators - Sri Lanka Hill Lands

- Build-up of soil behind Gliricidia hedge
- Locally adapted techniques of soil management
- Variable soil depth on terrace
- Crop growth changes according to erosion
- Soil surface indicators: micro-pedestals, rills, armour layer
- Compare soil colour between eroded and non-eroded parts

These are the sort of benefits that farmers have told us they appreciate
3. Carbon Sequestration

*Atmospheric levels of CO₂* have risen from preindustrial levels of 280 parts per million (ppm) to present levels of 375 ppm.

*Carbon sequestration* refers to the provision of long-term storage of carbon in the terrestrial biosphere, underground, or the oceans so that the build-up of carbon dioxide (the principal greenhouse gas) concentration in the atmosphere will reduce or slow.
Terrestrial Carbon sequestration

**Definition:** The net removal of CO₂ from atmosphere into terrestrial pools of C

**Process:** Photosynthesis

**Storage:**

- Soil organic C
- Inorganic C deep in soils
- Roots
- Soil carbon - the major part of the global C pool

<table>
<thead>
<tr>
<th>Pool</th>
<th>Amount of carbon (Gigatons – 10⁹ t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>750</td>
</tr>
<tr>
<td>Soil (organic)</td>
<td>1400</td>
</tr>
<tr>
<td>Soil (inorganic)</td>
<td>930</td>
</tr>
<tr>
<td>Living vegetation</td>
<td>760</td>
</tr>
</tbody>
</table>

- Soil C > 3 times Atmos. C
- Soil C > 3 times C in all vegetation
- 60% of all global C is in the soil
- But organic soil C is transient and volatile

NB – the oceans have 38,000 Gigatons – 10 times all terrestrial & atmos. C
Sustainable Land Management and Its Relation to Climate Change – Michael Stocking

Agricultural C-sequestration

- Develop diversified annual cropping systems to replace monoculture
- Add organic matter amendments
- Practices that minimize soil disturbance
- Retain residues

Tillage vs. No-Till
Terracing and agro-forestry

Practices that maintain and restore soil organic matter
Sustainable Land Management and Its Relation to Climate Change – Michael Stocking

**Issue 1 - Technical Potential**

Changing land management practices can restore soil C

Annual average rate of C accumulation = \((C_C - C_V)/(T_2 - T_1)\)

What happens after \(T_2\)?

**Issue 2 - Saturation**

- Sequestration accumulates C until absorptive capacity is used up
- 10-15 years for tillage [Source: West & Post]
- 30-70 years for forest carbon. [Source: Birdsey]
- Majority of gains occur in first years

Gitz et al 2004
Sustainable Land Management and Its Relation to Climate Change – Michael Stocking

Issue 3 - Volatility

- When practice is discontinued, most C released quickly
- Essential to encourage and maintain sustainable land management

Conclusion

- Linking SLM and CC technically possible
- Many opportunities exist, but
  - Exploit the synergies
  - Beware the complex processes
  - Calculate the cost
  - Utilise local knowledge
- Suitable policies and strategies needed to create an enabling environment