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Viewpoints

The *Natural Resources Forum* is running a special series over the 2007–2009 period on themes to be considered by the United Nations Commission on Sustainable Development in its 16th and 17th sessions: Africa, agriculture, desertification, drought, land and rural development. The Viewpoints in this issue will focus on the impact of sustainable land management on climate change.

Experts address the question:
"How can sustainable land management contribute to mitigating climate change?"

Sustainable Land Management (SLM) is perhaps one of the best measures available to mitigate climate change in the Himalayan ecosystem. Climate change in this region can result in flash floods, droughts, land degradation, rapid glacial retreat and trans-boundary disasters. The farming communities can play a big role in mitigation with support from politicians, policy makers and donors. There are opportunities to change the land use system and the farming practices in this region to sequester green house gases (mostly carbon dioxide), or reduce emissions (mostly nitrous oxides and methane) through use of minimal chemical fertilizers and improved livestock management. For example, the farmers can switch from shifting cultivation to an agro-forestry system, can change cropping patterns, and introduce hedgerows of grasses or tree species along the contours of sloping arable land.

The extent of land degradation in the Himalayan region is also increasing because of the growing population pressure on limited land resources. It is feasible to change these degraded or barren areas into rangeland, social forestry, and other plantations that could benefit the local environment and the farming communities who are dependent on small land holdings. These changes are possible if SLM technologies can generate immediate income to farmers, policy and legal supports are available, and donor communities are willing to invest in the long-term returns from these interventions.

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Managing land resources can help in two main ways: 1) by creating built landscapes that have low greenhouse gas emissions reducing mobile and stationary sources of those gases; and 2) by conserving landscapes that are natural sinks for carbon dioxide, like forests, and natural storage zones like tundra permafrost. But sustainable land management (SLM) for this purpose is not merely about the outcome: low climate impact land use/land cover. It must also be about a process that differs from conventional land management policy and practice in some key ways: it would compare existing land use and land cover practices with alternatives using the climate impact criterion, as well as other impacts; and, it would involve a dialogue about how to use land resources in a more sustainable way among different interest groups, including land managers, urban planners, transportation planners, energy planners, policy makers, community members and others. SLM can also contribute by being the systems framework within which activities such as transportation, energy use, power generation, industrial production, forestry and agriculture interact, creating an integrated, multi-sectoral response appropriate to meeting the climate change challenge.

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Climate change, food production, energy generation and environmental pollution are among the most important issues facing mankind today. There can be strong negative interactions between measures to tackle each issue individually and the race is on to identify technically feasible and cost effective ones that will benefit all. Increasing soil carbon could offset climate change and have beneficial impacts if linked with productive agriculture and energy generation in positive ways to reduce environmental pollution. The slow combustion of organic material produces 'biochar', a form of charcoal that is stable in the soil.

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Biochar may prove to be a valuable tool for mitigating climate change through sustainable land management.

In addition to providing a near-permanent sink for atmospheric CO_2, laboratory studies of soil and nanoscale investigations of individual biochar particles have suggested that biochar causes the retention of other organic matter in soil and suppresses the emission of greenhouse gases, nitrous oxide and methane.

Through possibly, a combination of direct and indirect biological, physical and chemical effects, the application of biochar to soil has been shown to dramatically benefit crop productivity under a range of tropical conditions. At the moment, the mechanisms and particularly their interactions have not been fully elucidated and there is a need to step up research on the potential of biochar for sustainable land management for climate mitigation.

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Sustainable land management is not a means to mitigate climate change but an end in itself. Of course, sustainable land management may be helpful but its impact is not really clear, especially now that climate change is under way. Linking land management to climate change can become problematic when it is shown that sustainable land management is not the most effective way to mitigate climate change. For policy makers, then, it would be attractive to channel funds from sustainable land management to energy efficiency or other measures to combat climate change.

Unsustainable land management has created a lot of environmental and social problems, like the loss of biodiversity, desertification, etc. and has resulted in economic problems too, especially increasing dependence on one or a few products. Putting a halt to unsustainable land management is a responsibility for all those countries who still engage in these practices. Unfortunately, there seem to be few countries that have escaped unsustainable resource use.

The main route to sustainable land management would include convincing the rural population to increase the diversification of their crops and cattle types at the local level and to refrain from overstretching the capacity of their natural resources. Improving resilience is key here. To do so requires secure access to land and water, financial resources, agricultural technologies and marketing techniques, as well as access to markets. At the country level, the rural population is in need of effective institutions and organizational power and influence to advocate their need of resilience.

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The impacts of climate change in India and south Asia are mainly due to increased precipitation and the rise in sea level. This has two types of impact depending on land use. If the land is predominantly agricultural, the regular crops grown during the monsoon will decay as the roots rot due to excess precipitation. A traditional paddy would be an exception where crops thrive in stagnant water.

To combat this would require planning for adequate water drainage and more importantly, research on water resistant crop species would need to be developed. Plant geneticists are now talking of modifying Fungi genes to make them do things like increase methane production for biogas or check for hospital waste in sewage etc. Therefore, there may also be potential for them to be modified to resist standing water.

In cities or towns, impact on land due to flooding and property disruption will be the greatest. According to one study, in Mumbai city alone, the estimated monsoon flood causes losses of Rs. 200 Cr as per 1992 prices. Thus better planning of housing by using raised platforms for houses or creating localized small flood shelters with storage of emergency food and more importantly 'safe' water and medication, would go a long way towards mitigation.

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Agroforestry land management practices, where trees and crops are integrated on the same land at the same time, can maintain soil carbon (C) stocks via the input of tree prunings and crop residues. Additionally, these systems can sequester C in the above- and below-ground tree components. As such, agroforestry systems serve a dual purpose by maintaining soil fertility to ensure a sustainable source of food for a growing population, and by mitigating global warming through sequestering C in the soil and tree component. This agricultural management practice also increases the resilience and the adaptability of agroforestry systems to a changing global climate. Until recently, agroforestry systems have been ignored in the C sequestration process because of their overall small influence on the global C cycle. However, several studies have shown that agroforestry systems do contribute significantly to sequestering atmospheric C in the soil because of their high return of organic material to the soil. In Costa Rica as much as 876,700 ha of land exists on which agroforestry systems could be established. Using this potential land area available for agroforestry systems, a total of 9.6×10^5 Mg C per year could be sequestered in the soil. Because of this large potential to sequester C in the soil, Costa Rica has developed a new policy that includes agroforestry land management practices in its payment for environmental services system. As such, in tropical biomes agroforestry land management practices have advanced our understanding of how to maximize the long-term sequestration of C in soil and how to simultaneously meet the increasing demand of a growing global population for food production. Further research has shown that a similar potential exists in temperate agroforestry systems.

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Crisp air, abundant fresh water and productive land characterize a pleasant habitat. Agricultural activities contribute approximately 20% of the annual increase in anthropogenic greenhouse gases; ecologically sustainable agriculture contributes to mitigating climate change through lowering this rate. Conversion of rangeland and forests to rainfed farmland, thus erosion of their soil, lowers their primary productivity, groundwater recharge and carbon sequestration potential. Sustainable indigenous biodiversity management conserves natural resources and generates a higher income through eco-tourism, trophy hunting, deferred grazing, and sale of truffle, fuelwood and medicinal plants; this also saves on the non-renewable energy (NRE) used in farming operations.

Legumes replace some nitrogen fertilizer for the succeeding crops; 1.7 m^3 of natural gas or 1.1 litres of petroleum is consumed in the production of 1.0 kg of N-fertilizer. Decomposition of these plants produces less N_2O than that of N-fertilizers.

Spate irrigation of shelter-belted farmland and pastureland mitigates dust storms, sequesters carbon and ameliorates the weather; this also reduces the NRE spent in pumping water, and in heating and cooling living spaces.

Qanat has sustained the Iranians for millennia through gravity-assisted flow, thus saving on the NRE spent in pumping water. These, collectively, offer a hope for sustaining *Homo sapiens* on the planet Earth.

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The linkages between biodiversity loss, greenhouse gas emissions and the degradation of ecosystems are perhaps most obvious when the very basis of production is lost — namely, soil.

Globally there are more than 1,800 different species of earthworms while a single gram of soil may contain as many as 20,000 species of soil bacteria. Together this soil biodiversity maintains nutrient cycling and sequesters carbon. And yet, we are currently losing biodiversity at a rate that is 100 to 1,000 times greater than the natural rate of extinction.

It has been shown that the conversion of natural ecosystems to agricultural land can deplete the soil organic carbon pool by as much as 75% in tropical regions. And yet, worldwide, as much as 63% of soils have been degraded — losing carbon and biodiversity.

The maintenance of soil biodiversity as a key component of sustainable land management can therefore provide significant benefits for climate change mitigation. This is particularly true of soils in peatlands and other wetlands which cover only 3–4% of the world's terrestrial surface but store 25–30% of the carbon contained in both terrestrial vegetation and soils.

The 2010 target to significantly reduce the rate of biodiversity loss, adopted by 190 of the Parties to the Convention on Biological Diversity when applied to soil biodiversity and the conservation of wetland systems can therefore contribute win–win–win scenarios for biodiversity, sustainable land management and climate change mitigation for the benefit of life on Earth.

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Climate risks are likely to have a great impact on global food security. The impacts on crop production will be more frequent moisture stress resulting from changed rainfall patterns and increased evaporation caused by higher temperatures. Poor and shallow soils will enlarge the problem due to the reduced resilience in the crop growth environment. Conservation agriculture (CA) would improve the productivity and sustainability of cropping systems in the face of climate change challenges. It is based on three management principles: (i) reduced/zero tillage (ii) maintaining crop residue on the soil surface (iii) inclusion of crop rotations. CA results in increased water infiltration, soil chemical, physical and biological fertility, water use efficiency, decreases soil erosion and creates an environment more resilient to drought and heat stress. CIMMYT* long-term trials have clearly indicated that improved germplasm does not achieve its genetic yield potential without good cropping systems management: the same wheat or maize variety with similar input use but different planting/tillage method and residue management results in yield differences up to 45%. Global food security within the context of the increased climate risk requires the combination of improved germplasm combined with appropriate agronomy in order to guarantee the potential of the germplasm is fully expressed.

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CO_2 is released when vegetation is cleared and burned and when soil organic matter is mineralized. Conversely, vegetation and soils sequester carbon. Incidentally, the increasing rate of the release of CO_2, has given rise to the current discussions on the Reduction of Emissions from Deforestation in Developing Countries (REDD) in the climate change negotiations.

Global terrestrial carbon stocks amount to between 2,221 Pg C and 2,477 Pg C. Of this, 1,567 Pg are held in the soil and 657 Pg C are held in plants (IPCC, 2001). These are substantial amounts when compared to the atmospheric carbon pool, which is about 760 Pg C (Lal, 2003). Drylands generally do not store large amounts of carbon in vegetation, but because of their extent (over 40% of the earth's surface), they have large carbon storage potential.

Vital as a carbon sink, forest ecosystems store 335–365 Pg of carbon in their biomass alone with the total C storage in the biomass, dead wood, litter and soil of forest systems, exceeding total atmospheric carbon (FAO, 2006; MA, 2005).

Against this background Sustainable Land Management (SLM) can contribute significantly to mitigating climate change, through practices that keep as much carbon sequestered as possible.

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Mitigating climate change is the reduction or elimination of any causes that may be responsible for CO_2 and other GHG emissions. These are largely the result of traffic emissions, and a function of the distances between land uses. It is clear that the strategy associated with the allocation of different uses will determine, to a greater or lesser extent, the need to travel and, consequently, the need to use motorized transportation. Land management can only be sustainable if the need to use motorized vehicles is reduced by participating in closer activities, preferably within walking or cycling distance, and by replacing private vehicles with efficient, carbon-free, public transport.

Emissions are also derived from industrial activities, and to a lesser extent residential, tourism and agricultural activities. Other major emission sources are forest fires which, provided extreme temperatures and drought, tend to be quite frequent. Land management is critical since it has to do with decisions regarding the allocation and licensing of such activities.

Therefore, sustainable land management's key priority needs to be the balanced distribution of land uses, to enhance synergies, avoid conflicts, and promote the economic value of land, human and natural values, while inducing a carbon-free lifestyle.

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Sustainable Land Management (SLM) aims to fulfill the needs of present populations without jeopardizing the well-being of future generations.

Sustainable exploitation of natural resources should, therefore, manage to prevent deep alterations of ecological parameters of the environment.

Global climate change is the result of several phenomena, the most important of which is inducted by non-responsible and unsustainable land management practices. Moreover, the huge production of CO_2 by highly developed countries is partially due to the heavy mechanization of agriculture and agricultural related industries such as fertilizer, pesticide, and herbicide plants.

Thus, by reducing the magnitude of these phenomena, SLM will make a large contribution to mitigating climate change. One of the problems though, is how to get farmers to adopt SLM practices, especially the poorest ones of underdeveloped regions and the richest most profit-oriented ones of developed countries.

SLM should consider poverty alleviation and moderation of profit seeking as some of the most important of its fields of action. This could lead to adoption of responsible and sustainable practices of natural resources management and possibly contribute to global climate change mitigation.

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Climate change increases the impacts of any perturbation, therefore, management schemes that increase ecological resilience are needed to mitigate climate change — both for the natural systems themselves and for the societies that are often critically dependent upon these systems. Climate impacts are invidious and it is the subtly increasing nature of these impacts that demands legal and policy responses on the part of national governments for resource management. Encouraging traditional users to adapt to new practices without a ‘smoking gun’ of immediate climate change impacts is ineffective. Law is the only tool strong enough to ensure that resilience maximizing activities are undertaken. These activities must include ensuring that rivers continue to flow, that gene pools are maintained and gene flow is encouraged, and that biomass and ecosystem productivity is maximized. International watershed management treaties, ecological refuges and protected corridors between them, and market incentives along with appropriate resource subsidies are all appropriate policy responses to encourage ecological resilience. Unfortunately, they also require a political will to act on timelines that exceed elective office terms and do not provide immediate tangible benefits. Sustainable land management will occur, the question is how long we delay and allow the costs to grow.

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Sustainable land management involves changes in land management that increase natural capital and reduce negative environmental impacts. These changes mitigate climate change by sequestering carbon in soils and biomass, and reducing emissions from degradation and inefficient practices. Conservation agriculture, a key strategy for sustainable land management on croplands, provides a good example. The system includes a range of resource-saving crop production practices, with reduction or elimination of tillage, increase in soil surface cover, and diversified crop rotations (FAO, 2001). These practices increase soil organic carbon — an important form of natural capital that contributes to soil fertility and agricultural productivity. They also sequester carbon in agricultural soils, a potentially significant source of climate change mitigation (IPCC, 2007). Improving rangeland management is another example of a sustainable land practice that can provide a significant source of mitigation (IPCC, 2007). Sustainable land management can improve incomes and livelihoods for many poor rural producers, and generate relatively low cost climate change mitigation. However, barriers like lack of credit, information, property rights and food insecurity prevent adoption. Carbon finance could help overcome these problems, but modifications in institutional arrangements to reduce transaction costs and support investment capacity are needed (FAO, 2007). Linking agricultural development and carbon payment programs is likely to help.

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