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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

(Prepared by the Scientific and Technical Advisory Panel)

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ПРОГРАММА ОРГАНИЗАЦИИ ОБЪЕДИНЕННЫХ НАЦИЙ ПО ОКРУЖАЮЩЕЙ СРЕДЕ
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Scientific and Technical Advisory Panel
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Preface

It is a pleasure to present the report of the Scientific and Technical Advisory Panel of the GEF on land degradation as a global environmental issue.

The report comes at a time when the Land Degradation Focal Area has completed its first 4 years of existence in GEF-3, and when a more mature, coherent and focused scope for the GEF's land degradation interventions has been called for in GEF-4. One of the key lessons learnt in GEF-3 has been the difficulty in distinguishing what constitutes global benefits in sustainable land management (SLM). This prompted the GEF Council to urge its Secretariat and associated agencies, including STAP, to provide greater clarity on the issues of global benefits and incremental reasoning in the focal area.

To support the GEF process to address the concerns of the Council, STAP undertook in the period February to July 2006 three comprehensive studies on land degradation in the GEF, to provide a scientific rationale and guidance for the future developments of the focal area. This report is a synthesis of the three studies, which will be made available in full at the next Council meeting following peer review.

The conclusions that can be drawn from the studies are: the clearest and best-researched linkage is between land degradation and climate change; that international freshwater basins are critically linked to the status and function of terrestrial ecosytems; there are significant gaps in our knowledge in how land degradation affects vegetation productivity but also how a change in productivity has knock-on effects on biodiversity; and that numerous indirect impacts on the global environment occur through impacts on human society. These indirect but cumulative effects need significantly increased attention, as part of a combined global environmental and development action strategy.

The report presents a number of recommendations for advancing the relevance of land degradation investments by the GEF, and identifies priority topics in SLM for the GEF. Some of these topics are particularly suited to achieving global environmental benefits as incremental activities in development projects and in the work of other agencies such as the CGIAR.

The report urges the GEF to accept that land degradation is one of the greatest threats to the integrity of ecosystems, and to continue to capitalize on its substantial institutional advantage in funding investments in cross-focal area linkages and in further developing integrated approaches that are fully inclusive of SLM.

The report was prepared by Prof. Michael Stocking, Vice Chair of STAP.

Yolanda Kakabadse
STAP Chair

BACKGROUND TO THIS SYNTHESIS STUDY

1. At the start of GEF-4 and with a reaffirmation of the importance of addressing sustainable land management (SLM) from the 3rd GEF Assembly in Cape Town[1], there is a vital need to learn lessons and draw strategic directions for future investments in SLM in the LD FA that will bring clear global environmental benefits and address the concerns of GEF Council. A more mature, coherent and focused scope for the LD FA has been called for in GEF-4.

2. One of the key lessons learnt has been the difficulty in distinguishing what constitutes global benefits in SLM. Globally significant impacts from investments in this focal area must be demonstrated. Having noted that "land degradation has become a threat to the global environmental commons [through] desertification, deforestation, loss of biodiversity, adverse effects on climate, sedimentation and pollution of international waters"[2], the GEF Council urged its Secretariat and associated agencies, including STAP, to provide greater clarity on the issues of global benefits and incremental reasoning in the focal area. In addition, the Council requested the development of relevant indicators of results and performance by 2008.

3. The GEF Inter-Agency Task Force on Land Degradation initiated a 2-year process to address the concerns of Council. It requested the assistance of STAP in order to provide a sound scientific input to this process. The Millennium Ecosystem Assessment was to guide the development of thinking as to how to integrate the focal area in a scientifically appropriate away into GEF's Operational Program 15 on Sustainable Land Management. Further, the Task Force would guide the development of LD FA indicators that would provide evidence that investments in SLM achieve significant global impact. An MSP on measuring impact in the LD FA using an indicator system, coordinated by UNDP with the technical assistance of UNU-INWEH, was requested to assist with this task.

4. To support these initiatives, STAP undertook in the period February to July 2006, three comprehensive studies on land degradation issues in the GEF that would bring together eminent scientists and experts to respond to the Council's concerns and provide a scientific rationale and guidance for the future development of the focal area. These studies were: (1) **Global Impacts of Land Degradation** which was intended to review the scientific evidence to support LD as a legitimate topic of global relevance to GEF; (2) **The Millennium Ecosystem Assessment (MA) Methodology and Land Degradation** which was intended to show how global environmental benefits of LD interventions could be determined using the MA's ecosystem services framework; and (3) **The Trade-offs Between Sustainable Land Management, Global Environmental Concerns and Local Socio-Economic Impacts** which would focus on how LD projects could determine the land use trade-offs between GEF focal areas and development issues.

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[1] Cape Town Statement: Consensus of the Forum for Sustainable Land and Water Management at the Third GEF Assembly, Cape Town, South Africa, August 28, 2006. Extract para 9: "In view of the critical state and trend of land degradation, GEF and its partner agencies are urged to focus on activities that will result in a significant reduction in land degradation and its damage to ecosystem services and to the poor."

[2] *Scope and Coherence of the Land Degradation Activities in the GEF*. GEF Council June 3-8, 2005. Agenda Item 9. Document: GEF/C.24/6/Rev.2, May 18, 2005

5. This paper summarises the salient conclusions of the three STAP studies and draws lessons and recommendations for GEF in further developing its strategic approach to the LD FA and guiding future investments in SLM in order to address gaps in the scientific knowledge and areas where investments will achieve greatest global environmental benefit. It situates its conclusions in the context of the four Strategic Priorities of the LD FA:

SP1: Foster system-wide change and remove policy, institutional, technical, capacity and financial barriers to sustainable land management

SP2: Demonstration and up-scaling successful sustainable land management practices for the control and prevention of desertification and deforestation

SP3: Generating and disseminating knowledge addressing current and emergent issues in sustainable land management

SP4: Cross focal area synergies and integrated ecosystem approaches to watershed-based sustainable land management

THE GLOBAL IMPACTS OF LAND DEGRADATION

6. Land degradation has multiple and complex impacts on the global environment through a range of direct and indirect processes affecting a wide array of ecosystem functions and services. These impacts are captured in almost all of GEF's focal areas of interest. Impacts also occur on global development issues, especially food security and human health. An analysis from the scientific literature of the severity and importance of these impacts suggests that the process linkages may be graded according to the degree of sensitivity involved and the certainty of the impacts creating a dangerous condition consequent upon land degradation. The summary table of these linkages and a matrix indicating degree of severity is attached here at Annex I.

7. The clearest and best-researched linkage is between land degradation and **climate change**. Land degradation interrupts the regulating and provisioning services of ecosystems, in particular nutrient cycling, the global carbon cycle and the hydrological cycle. SLM critically depends upon the efficient functioning of these cycles. For example, carbon pools in soil and above-ground vegetation, particularly forests, are very large but easily disturbed. They are affected by unsustainable land management practices and by the type of LD that is prevalent (e.g. water erosion; deforestation; soil compaction). Estimates of historical contributions of agriculture to atmospheric CO_2, the amounts and rates of carbon lost as a consequence of deforestation and conversion of land to agriculture and other soil-vegetation-atmosphere carbon fluxes, all suggest that LD has had a very significant impact, through raising atmospheric CO_2 concentrations, on climate. Future impacts are certain.

8. With regard to **biodiversity**, ecosystems provide the habitats for all living organisms. Disruption to ecosystem functions inevitably diminishes the diversity of above- and below-ground biodiversity, as well as affecting aquatic life. The potential impact of deforestation on above-ground biodiversity is especially large and well documented. Impacts of other forms of LD on biodiversity are less clear with effects on below-ground biodiversity likely to be the most

severe. There are significant gaps in our knowledge here, not only in how LD affects vegetation productivity but also how a change in productivity has knock-on effects on biodiversity. Anecdotal evidence is common, but the science is sparse. Variability in the sensitivity of different ecosystems to LD and the biodiversity they contain mean that many focussed studies are required to assemble an aggregate estimate of the global impact. In SLM, an international database on the quantitative relationships between LD and vegetation production would be important. Existing information is scattered and partial.

9. In the **international waters** focal area, international freshwater basins are critically linked to the status and function of terrestrial ecosystems. Pollution of these basins as a consequence of LD is common and the processes are well understood. In marine ecosystems, coastal zones are the most susceptible to pollution-related impacts arising from LD. There is evidence of global impacts as large stretches of coast can be affected, extending to reef and large marine ecosystems. There is growing interest in the impact and importance of land-derived dust deposits to ocean systems but this is an area of considerable uncertainty.

10. The contamination of water, ecosystems and food-chains by pesticides applied to or accumulating in soil is the best-verified impact linking land degradation with **persistent organic pollutants**. Soil erosion contributes to this contamination but other processes, not considered as LD, are also involved: e.g. normal drainage of water through the soil, the accumulation of soil-derived POPs by growing plants destined for food or feed. Targeted research to understand the processes and most appropriate points of intervention is indicated.

11. The direct impacts of LD on **human development** are normally outside the scope of GEF's remit; they are not environmental and tend to be local or national in extent. However, numerous indirect impacts on the global environment occur *through* impacts on human society. Any impact on a community that affects wealth, livelihoods, food supply, health, education, resistance to disease or migration will also affect a community's ability to manage the environment sustainably. It will put extra demands on global public goods such as biodiversity and ecosystems and will potentially challenge all of GEF's focal areas, including worsening further the status of LD. These indirect but cumulative effects need significantly increased attention, as part of a combined global environmental and global developmental action strategy.

12. There are significant **knowledge gaps and uncertainties** in our understanding of the global impacts of land degradation. From an analysis of the scientific literature, a list has been compiled (see summary in Annex I). Impact pathways are inadequately understood: for example, how air and water act as the media through which impacts of LD are transferred from local to global; also the role of food chains in the transfer of POPs; and social pathways in rural-urban and trans-boundary migration that transfer the impact of LD to other places. The impact of LD on climate change goes beyond GHG emission. Land surface change, especially deforestation, may have an effect on climate of a similar order to that of GHGs. Carbon sequestration effects of SLM may be offset by changes in land surface albedo. There are similar complex positive and negative feedback loop effects in other focal areas, which are only partially understood, but which should be key areas of scientific knowledge in order to prioritise investments in SLM by the GEF.

THE GLOBAL ENVIRONMENTAL BENEFITS OF LAND DEGRADATION INTERVENTIONS USING THE MA FRAMEWORK

13. The Millennium Ecosystem Assessment (MA) is an international scientific collaboration to improve the evidence base on the current condition of global ecosystems, the drivers of change, and possible management interventions. The assessment is based around the ecosystem approach to conservation, which stresses the integration of local, national and global ecosystem processes and their links to human well-being – see Annex 2 for a diagrammatic representation and brief description. The MA, therefore, provides a framework for integration across scales of operation where environmental change occurs, and it explicitly links how these changes affect global aspects of human welfare. However, the MA was not designed with GEF modalities in mind.

14. The MA approach makes three important contributions to the LD FA: (1) it emphasizes the ecological dimension of land degradation – and hence the links with other environmental attributes that are accepted as global - through its focus on ecosystem services; (2) it emphasizes the link between land degradation and human wellbeing – an accepted global concern - through both the drivers and ecosystem services boxes of the MA framework (see Annex II); (3) through its systemic approach and global reach, it emphasizes the global environmental dimension and impact of land degradation. This third contribution is an outcome of the first two. Therefore, the MA has the *potential* to provide the needed guidance as to project approaches that are eligible for GEF support.

15. However, in its advocacy of the ecosystem approach, the MA is more conceptual than practical. By itself it provides limited evidence as to how ecosystem services can be translated into tangible policy or specific actions for achieving global environmental benefits or of promoting human welfare. What the MA does do successfully is to marshal existing ecological and socio economic approaches into a more integrated understanding of ecosystem change and its potential impacts on well being. But it does not yet offer any clear methodological guidance that can be used by GEF applicants under Operational Program 15 (SLM) to substantiate the global credentials of project proposals.

16. Nevertheless, by stressing the importance of ecosystem integrity and the links between local ecosystems and global outcomes, the MA provides some lines of reasoning for the relevance of the LD FA to the GEF global project portfolio in at least the following three ways: (1) all ecosystems are unique and therefore globally valuable; (2) ecosystems are themselves linked, from the local to the global, so that change at the local scale induced by land degradation has consequences at larger scales; and (3) there is a class of truly global ecosystems and global land degradation stories that can demonstrably fit the GEF global template. However, there are problems with these lines of argument. The first is impossible to verify. It is a similar argument to the loss of biodiversity – how can the loss of unknowns be known? The second is verifiable, but it is also known that ecosystems have resilience, so change at a very local scale may not have an impact that is significant at the larger scale. There could be ways of identifying and prioritising actions that prevent those local changes that have greatest significance for, say, international waters and climate change. The third uses trans-boundary externality arguments that are already well accepted by the GEF.

17. One of the key benefits of determining global environmental benefits through an ecosystem services approach is that it reveals dimensions of global environmental benefits that are not so visible in more traditional approaches. Cultural services, for example, identify important aspects of sustainability that are not seen in a more traditional approach based on just land degradation processes. Another benefit of using an ecosystem services approach is that it captures different constellations of ecosystem services that are provided by different interventions and combinations of interventions. This facilitates the analysis of trade-offs between local and global environmental benefits – see Trade-offs Section below. Working with the concept of ecosystem goods and services thus has a number of *potential* benefits for the LD FA that go beyond the requirements of a method of calculating incremental costs to address global environmental benefits.

TRADE-OFFS BETWEEN SUSTAINABLE LAND MANAGEMENT, GLOBAL ENVIRONMENTAL CONCERNS AND LOCAL SOCIO-ECONOMIC IMPACTS

18. Sustainable Land Management (SLM) has proven co-benefits (i.e. synergies, positive feedback loops or positive trade-offs) for biodiversity conservation, mitigation of (and adaptation to) climate change and the protection of international waters. It has even stronger potential synergies with enhanced rural livelihoods and human well-being where SLM is translated into greater biomass production and improved productivity.

19. SLM may have negative consequences on other global environmental concerns. Land use impacts on natural biodiversity may contribute to climate change from release of carbon from the pool of soil organic carbon. It may generate issues of societal concern through change in land use and cover. It is therefore important to identify the likely negative consequences of a programme or project in the LD FA before it begins and set measures to mitigate the impact. Further, it is imperative to use a trade-off analysis to prioritise those projects that create co-benefits above those that have negative consequences.

20. Trade-off analysis should seek to provide a balanced and well-informed outcome, through a decision process that reaches a conclusion with minimum conflict, cost and delay. Stakeholder involvement is essential. There is no one technical method by which to reach a decision in an indisputably optimal way. Nevertheless, technical analysis should be part of the process, using quantification of impact outcomes wherever possible. Making intelligent trade-offs is especially difficult when local and global interests, or short-term versus long-term impacts, need to be balanced.

21. SLM as supported by the GEF addresses three categories: sustainable agriculture; sustainable rangeland and pasture management; and sustainable forests and woodland. Similar broad trade-off considerations apply to all three areas. However, for rangelands and forests in particular, where the natural ecosystem processes are largely maintained, a different set of trade-offs from those invoked in agriculture may apply. These trade-offs are more likely to involve synergies between the global environmental change topics, such as a balance between rangeland productivity and loss in biodiversity. Agriculture involves land cover change and processes that are substantially altered from the natural condition. Trade-offs here must include global

developmental as well as environmental change, such as the co-benefits of SLM for food security. This social dimension in terms of impacts on livelihoods, especially of the poor, is becoming an overarching objective of the GEF and its partners and should be explicitly recognised.

22. Key issues in considering trade-offs in the LD FA include: the often common occurrence of positive trade-offs, which should be identified and prioritised for investments. In some situations, trade-offs may suddenly increase beyond a certain level of SLM action (i.e. there is a 'non-linear response'). Identifying critical thresholds is essential in the project decision-making process regarding trade-offs. There is an important inter-generational equity element in considering trade-offs: current benefits or costs must be weighed against future benefits and costs. Considering future interests is a responsibility of all parties, especially those dedicated to sustainability. Finally, there are issues related to scale in trade-offs. Positive and negative tradeoffs may be experienced simultaneously at local, regional and global scales. There are, therefore, needs to consider trade-offs between stakeholders at the different scales. Global organisations with a mandate for the improvement of human wellbeing have a particular responsibility to see that these trade-offs are dealt with equitably.

23. A six-step procedure for determining trade-offs is proposed (see Annex III) as a pragmatic approach to determining likely impacts and quantifying tradeoffs in SLM. The steps are based on widely-accepted Environmental Impact Assessment methods and designed to be inexpensive and sufficient to perform a 'triage' for decisions: (1) the project is unlikely to be viable as a result of large, negative consequences on non-SLM social objectives; (2) there are reasonable grounds to suspect that one or more significant negative impacts *may* exist, but further information needs to be gathered before an informed decision can be made; and (3) no major negative consequences are envisaged. Given the multi-criteria, value-based nature of any decision to proceed or to reject, the process should be stakeholder-based, rather than technocratic. If the decision is to proceed, mitigation actions should be put in place to limit negative tradeoffs.

RECOMMENDATIONS FOR ADVANCING THE RELEVANCE OF LAND DEGRADATION INVESTMENTS BY THE GEF

24. **Global Environmental Benefits (GEB) in LD control and SLM**. Principle 2 of GEF's Operational Strategy for the development and implementation of the work programme states that: "The GEF will provide new, and additional, grant and concessional funding to meet the agreed incremental costs of measures to achieve agreed global environmental benefits."[3] The three studies commissioned by STAP, of which this report is a synthesis, all converge in their overall recommendations that GEB's are indeed generated by investments in sustainable land management. The first study identifies the scientific evidence for the global impact of land degradation, concluding that there are a number of ways that investments in SLM derive global benefits, both environmental and developmental. The second study shows how sustainable land management reaches across local to global scales of impact through a consideration of the

[3] GEF, 1995. Operational Strategy of the Global Environment Facility. Box 1.1 http://www.gefweb.org/Operational_Policies/Operational_Strategy/operational_strategy.html

ecosystem services that are affected by LD and improved by SLM. The third study describes co-benefits achieved by SLM and suggests a technical procedure to identify these through analysing and prioritising positive trade-offs that generate GEBs. Minimising negative trade-offs by employing sustainable land use options could itself be an agreed GEB.

25. Land degradation affects global public goods and the integrity and function of ecosystems. The global credentials of the LD FA are supported through considering the irreversible disruption caused to ecosystem functioning by land degradation. Ecosystems are unique and therefore directly they are globally valuable. Ecosystems regulate, service and provide for human welfare and development. Land degradation undermines many of the fundamental processes, especially nutrient, water and carbon cycling, which underwrite the integrity of ecosystems. Many of these processes are well researched and understood. In their own right, the control of LD and the promotion of SLM bring global benefits through enabling ecosystem processes to function and protecting ecosystem integrity. The GEF is urged to accept that ecosystems are unique; their existence value[4] is a global value; and land degradation is the single greatest threat to the integrity of ecosystems.

26. **Defining global environmental benefits**. Defining 'global' in purely spatial terms is not only problematic for the LD FA but also for biodiversity and climate change. GEF should consider defining global environmental benefits in terms of common global concerns and common global processes. The Millennium Ecosystem Assessment framework offers opportunities in this regard for LD and SLM by making operational the concept of categories of ecosystem services that support, regulate and provide cultural services. Incremental financing under GEF would typically support cross-generational and common concerns of humankind, and these would achieve what would be defined as global environmental benefits under the LD FA.

27. **The MA and global environmental benefits**. The Millennium Ecosystem Assessment (MA) approach has the potential to make an important contribution to the determination of the global environmental benefits of land degradation interventions. The MA framework highlights the importance of ecosystem services and human wellbeing. Neither of these aspects is well served in more traditional approaches to LD and SLM. The concept of ecosystem services promoted by the MA helps to bridge the issue of global versus national environmental benefits. However, beyond this terminology, the MA requires more development and scientific work in order to be able to directly aid in the determination of global environmental benefits.

28. **Targeted research**. Though it is usually possible to identify potential incremental benefits in the control of land degradation and the promotion of sustainable land management, it is difficult with current evidence to show their extent and significance. GEF is recommended to consider carefully selected investments in targeted research to identify impacts with greater precision and to investigate the occurrence of positive and negative trade-offs or synergies. Examples could include research to quantify the linkages between environmental and developmental benefits and across focal areas. Such research would have a primary aim of

[4] Existence value: derived simply from the satisfaction of knowing that ecosystems continue to exist, whether or not this might also benefit others (also associated with 'intrinsic value').

supporting monitoring and evaluation of projects through providing the scientific evidence-base and techniques for assessing beneficial impacts.

29. **Priority topics in SLM for the GEF.** The first STAP study on global impacts of land degradation identified from the scientific literature the highest priority impacts of LD on the global environment, including two of the MDGs most closely related to SLM, food security and human health. Priority topics include: land use change on biodiversity; burning of biomass on dust and GHG emissions as well as human health; decline in soil organic carbon on GHG emissions and food security; land contamination by agro-chemicals on biodiversity, international waters and POPs. Some of these topics are particularly suited to achieving GEBs as incremental activities in development projects and in the work of other agencies such as the CGIAR. The GEF is urged to continue to support its substantial institutional advantage in funding investments in such cross-focal area linkages and in further developing integrated approaches that are fully inclusive of SLM.

ANNEX I: A sample of impacts of land degradation on the global environment and a summary of knowledge gaps.

(a) A sample of impacts of land degradation on the global environment.

LD Process	Variables	Climate change	Bio-div-ersity	Inter-national waters	POPs	MDGs	
						Food security	Human health
Land use change	Albedo	++					
	Evapotranspiration	++			++		
	Roughness	++					
	Vegetation cover	++		+		+	+
	Vegetation composition	++	+++	+		+	+
	Habitat loss		+++			++	+++
	Carbon loss from vegetation removal	+++					
	Land use conversion	+++				++	+++
Biomass burning	Aeolian dust emission	++					+++
	GHGs emission	+++					
	POPs emission				+++		++
Dust storms	Absorbing/deflecting incoming radiation	++	++	++	++		
	Nutrient cycle and deposition	+	++	++	++		
	Air pollution						++
Decline in Soil Organic Carbon	GHG emission from soil	+++					
	Microbial activities		++		++	+++	
	Soil nutrient availability		++	++		+++	
	Soil structure					+++	
Land	Agro-chemicals in soil		++	+++	+++	+++	

contamination	- in surface runoff		++	+++	+++		++
	- in sediments		++	+++	+++		++
	- in groundwater		+		+++		++
	- in food chain		++	++	+++		++
	- in atmosphere		++	++	+++		++
Irrigation	Biomass production	++				+++	
	Waterlogging	+				+++	
	Salinization					+++	
	Surface water extraction			++		+++	
	Groundwater depletion		++	++		+++	
Soil erosion	Soil redistribution	++	+++	+++	++		
	Biomass production	++				+++	
Habitation change (mining, road construction)	Land surface disturbance			++			++
	Landscape fragmentation		+++				

Qualitative degree of severity, sensitivity and certainty in the process linkage represented by:
+ = slight; ++ = moderate; +++ = strong

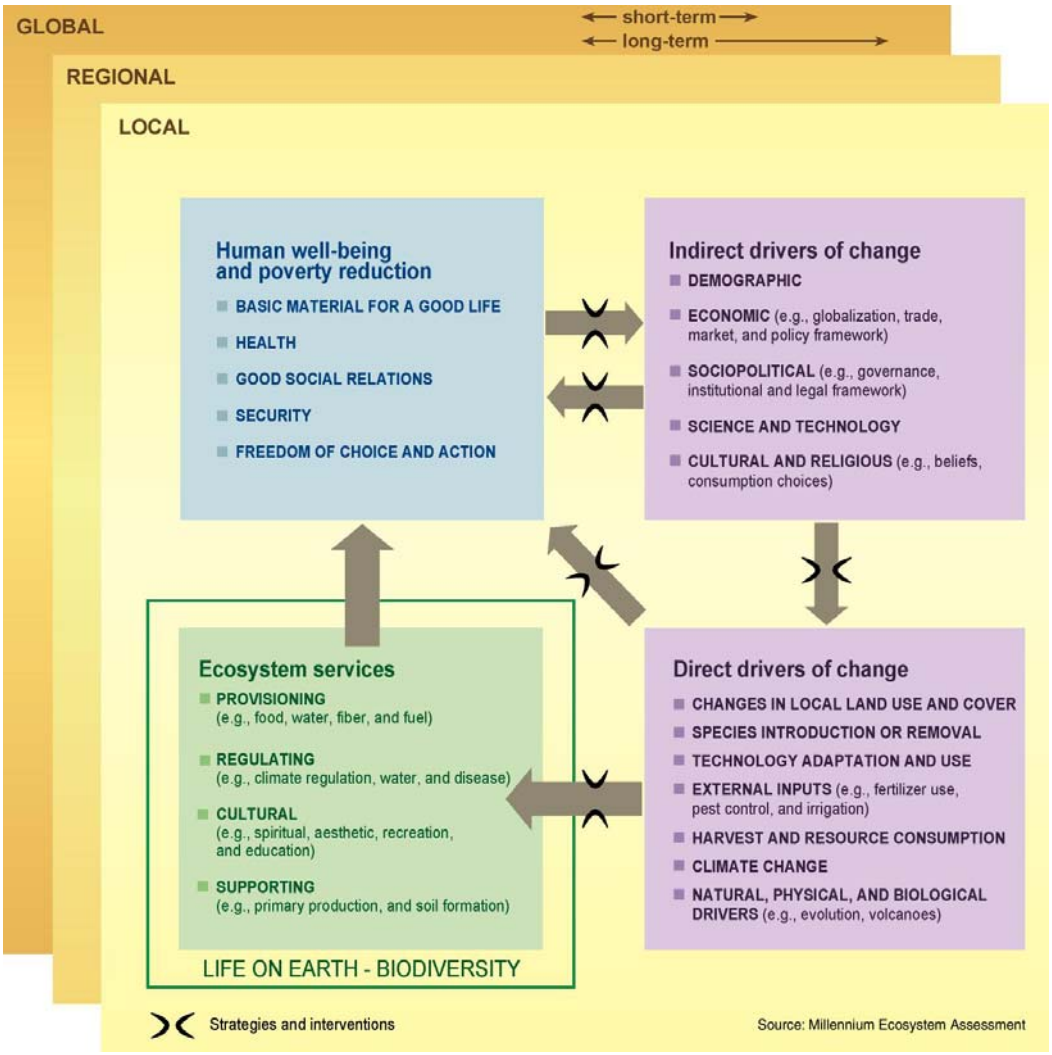
(b) A Summary of knowledge gaps

Targeted and fundamental research needs on global environmental impacts of land degradation

Impact	Know with some certainty	Need to know with greater certainty	Need to know
LD on ecosystem integrity	• loss of ecosystem connectivity • loss of ecosystem resilience [but not *how*]	• Ways of measuring the impacts of LD on ecosystem integrity	• Ecosystem services at global level • Strategies for restoration of degraded ecosystems • A monitoring and evaluation framework for LD impacts on ecosystem integrity
LD on CC	• Soil as a carbon pool in the global carbon cycle; • Land use change and deforestation, in particular, in the global carbon cycle; • Soil management changes sequestering carbon from atmosphere; • Agricultural land use as a major source of CH_4 and N_2O emission	• Land surface changes (e.g. albedo, roughness) in regional & global CC • Human activities and the occurrence of sandstorms • Biomass burning may contribute to CC • Contribution of changes in soil management to carbon sequestration	• The effect of CC on LD trends in different regions/systems • The impact of CC on soil as carbon sink or source • Potential of LD control technologies for soil C sequestration • Nature and significance of land/LD/climate feedbacks • The fate of carbon in eroded soil
LD on BD	• Deforestation and loss of habitat and species; • Land use change and management, including fragmentation and burning , and loss of habitat and biodiversity; • Non-point pollution from crop production and damage to aquatic habitats and biodiversity	• Methods (indicators) for measuring the impact of LD on BD	• Impact of biodiversity loss combined with climate change on land degradation • Impact of LD on below ground biodiversity and the impact of this on soil function
LD on IW	• Agricultural land use activities as a major source of pollution of IW • Land use and land cover change and the global hydrological cycle	• Atmospheric deposition of soil dust & coral reefs • Differentiation of impacts of LD from other land-based impacts • The pathways by which LD impacts on IW	• Integrated strategies for land and water management • Role of land degradation in the land-ocean-atmosphere linkage
LD on POPs	• Soil as a major pool of POPs • Soil organic matter content and microbial population as factors determining the fate of POPs • POPs transported by soil erosion and runoff as part of the LD process	• Conditions where soils release or sequester POPs • The extent to which biomass burning produces POPs	• Synergies for soil management and prevention of POPs damage

ANNEX II: The Millennium Ecosystem Assessment (MA) framework and brief description. Source: MA (2003)

The Millennium Ecosystem Assessment is a framework that ties human wellbeing and poverty alleviation to ecosystem services and direct and indirect drivers of change, as shown below.



The MA defines four categories of ecosystem services: Supporting services, provisioning services, regulating services, and cultural services. Supporting services are those ecosystem services that are necessary for the production of all other ecosystem services. Their impacts on people are either indirect or occur over a very long time. Provisioning services are the products people obtain from the ecosystem (these are sometimes also referred to as ecosystem goods). Regulation services are the benefits people obtain from the regulation of ecosystem processes. Cultural services are the nonmaterial benefits people obtain from the ecosystem (MA, 2003). The table below lists a sample of services that fit each category.

Of relevance to the LD FA and SLM is a wide array of services drawn from the four categories. Directly, land degradation and its control are captured by the regulating services of water and erosion control. Land degradation impacts on all provisioning services. Similarly, SLM is underwritten by the ecosystem processes of soil formation, nutrient cycling and water cycling, and by the provision of goods to society such as food, fuel and fibre. Cultural services are also well-represented in SLM through local or indigenous knowledge of conservation practices, and cultural diversity and social relations. Social assets, such as local groups and self-help networks, have been described as the 'safety net' for poor people in creating their livelihoods from the land (Dercon, 2002) and its sustainable use.

Table 1. An overview of the key ecosystem services

Supporting services	Provisioning services	Regulating Services	Cultural services
• Soil formation and retention • Nutrient cycling • Water cycling • Primary production • Production of atmospheric oxygen • Provisioning of habitat	• Food • Fresh water • Fuel wood • Bio-chemicals • (incl. natural medicines and pharmaceuticals) • Fibre • Genetic resources • Ornamental resources	• Climate regulation • Disease regulation • Water regulation • Water purification and waste treatment • Pollination • Air quality maintenance • Erosion control • Biological control • Storm protection	• Spiritual and religious • Recreation and ecotourism • Aesthetic • Inspirational • Educational • Sense of place • Cultural heritage • Cultural diversity • Knowledge systems • Social relations

Source: MA (2003).

Reference:

Dercon, S. (2002) Income Risk, Coping Strategies and Safety Nets. *World Bank Research Observer* 17: 141-66.

MA (2003) *Ecosystems and Human Well-being: A framework for assessment*. The Millennium Ecosystem Assessment. Washington DC: Island Press.

ANNEX III: A summary of trade-off issues of potential relevance to SLM and a six-step procedure for trade-off analysis.

(a) A summary of trade-off issues.

Trade-off with	Scale	Key issues
Climate change	Global	Main impacts are through the carbon cycle (generally positive) and albedo changes (often negative). If impacts are identified and need further analysis, the radiant forcing approach to quantify net impacts on climate change is suggested.
	Local	SLM will greatly affect vegetation cover, in which case the impacts are likely positive. LD is more likely to create a collapse of a current climate system than SLM to create a new local climate. Where scoping identifies local climate change as likely, specialist studies would need to be undertaken.
Bio-diversity	Global	Sustainable rangeland management and forest/woodland management may benefit biodiversity, but specific taxa may be adversely impacted. The likely impact of sustainable agriculture on biodiversity is less clear and will be case dependant. A key factor will be the impact that SLM has on bringing new land into agriculture. Landscape biodiversity measures are a quick and cheap method to approximate impacts. A species richness and abundance based measure would be needed if detailed monitoring of impacts is required.
	Local	SLM is likely to increase functional biodiversity. This should impact positively on the long term sustainability of livelihoods and agricultural production. Short term costs many be needed to gain long term benefit. Some enterprises may be negatively impacted (e.g. unsustainable timber harvesting, unsustainable grazing or the charcoal industry).
Water yield	Global	Impacts are possible for internationally-shared river basins. SLM is likely to have positive benefits on the quantity of usable water, though any activity requiring irrigation, the application of fertilizers or biocides, or the replacement of a low water-demand vegetative cover with a high water-demand cover needs careful consideration. SLM may lead to decreased stream flow. Second-order linkages between freshwater systems and international waters are possible.
	Local	There are possible impacts between water quality, duration and quantity. Trade-offs occur between upstream and downstream water uses, as well as between water quality, biodiversity and the livelihoods dependent on aquatic biodiversity.
International oceans	Global	The interplay between dust export from the land and productivity of international waters is a consideration if SLM will have impacts on land cover. SLM impacts via river flow (volume, pollution load, duration, silt load) is likely to have positive impacts on the coast and oceans, possibly of global scale if it spans an international EEZ border or reaches the open ocean.
	Local	Generally positive impacts via above mechanisms.
Poverty	Global	SLM activities in general result in a transfer of resources from wealthier regions to poorer regions. The efficiency of this transfer may be an issue.
	Local	The need for poverty reduction (especially in the short term) may have negative trade-offs with biodiversity. Over the long term SLM should help reduce poverty, but subtle trade-offs such as relating to equity of access, particularly of vulnerable groups need consideration. Short term vs. long term trade-offs in production is likely.
Economic development	Global	SLM activities need to result in increased development choices, rather than narrower options.
	Local	Development needs may clash with long term SLM objectives. Short term vs. long term trade-offs are likely

(b) A six-step procedure for trade-off analysis

STEP 1. Scoping of likely impacts
Best achieved through a participatory approach where key stakeholders (both local and global), as well as sector specialists, are used to identify likely impacts based on the project concept. A list of identified possible tradeoffs is developed.

STEP 2. Estimating the order-of-magnitude of tradeoffs
Sector specialists provide direction (negative or positive) and order-of-magnitude assessments of identified trade-offs, using the standard format of direction, magnitude (quantified, order-of-magnitude), scale, duration, certainty and significance (with and without mitigation).

STEP 3. Perform a 'triage', and invite comment from stakeholders
The first classification into 'show-stoppers', 'needs more investigation', and 'no problem' categories should be performed by the project champions, with assistance from the specialists. These decisions then should be tested by those with an interest in the outcome.

STEP 4. Detailed studies on high significance negative tradeoffs
If important potential negative impacts are identified in steps 1 to 3, but insufficient information or consensus exists to immediately terminate or approve the project, then detailed studies are required. Project champions draft the terms of reference and run a transparent process of appointing specialists. New primary data gathering is sometimes necessary, but in general the analysis is based on assessment of existing evidence and reasonable extrapolation to the specific context of the proposed SLM action.

STEP 5. Multi-criteria trade-off evaluation involving stakeholders
This is a value-based assessment of the balance between benefits and tradeoffs, done by those who have a stake in the outcome. The balance of considerations is likely to be different for local role players, primarily concerned with local outcomes, and global stakeholders, who need to consider trade-offs with other global environmental benefits. The use of multi-criteria decision support tools may be helpful in facilitating this process. Experience shows that if clear and agreed thresholds can be identified, below which the trade-offs are minimised, rapid convergence on an agreed action can be achieved. In the event of an impasse between different interest groups (either local vs global, or between conflicting social objectives), a 'higher level' conflict resolution mechanism is needed.

STEP 6. Determination of mitigation actions and setting of acceptable limits
If it is agreed to proceed, the impacts of trade-offs can often be managed through the establishment of mitigation activities. Where non-linear responses are likely, it is important to determine thresholds of acceptable change and set limits and monitoring systems so that the thresholds are not exceeded.