Global land and soil degradation: challenges to soil

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Abstract

This issue paper presents an overview of the current state-of-the-art scientific knowledge on land and soil degradation. It outlines a selection of the interactions between human and biophysical factors that can lead to different types of land and soil degradation, considering what this means for the continued provision of ecosystem services, in particular for those people most dependent upon the land for their livelihoods. It reviews the challenges in measuring land and soil degradation and identifying hotspots and bright spots; considers what these challenges mean for policymakers in interpreting information on the trends and dynamics of degradation; and reflects upon the steps necessary to move towards a world in which there is zero net land degradation. Throughout the paper, interdisciplinary examples and case studies from all over the world are used, demonstrating the multi-scale and coupled human-environment factors that can lead to land and soil degradation. The paper argues that a global approach to advance land and soil sustainability is urgently needed if the threat to sustainable development is to be reduced.

Keywords: monitoring and assessment; sustainable development; livelihoods; ecosystem services; land; soil; degradation, desertification

1. Introduction

Soil is considered one of the world's limited, non-renewable resources. Under cropland conditions, it takes between 200 and 1000 years for 2.5cm of topsoil to form (Piementel et al., 1995). The continued maintenance of fertile soil is essential in order to meet basic human needs. It underpins the provision of ecosystem services such as food production and climate regulation, and provides the basis of livelihoods for millions of people across the world (MA, 2005). Achieving the goal of land and soil sustainability requires an interdisciplinary approach, and provides an enormous challenge to policy makers, scientists and land users alike.

While land and soil resources are generally owned and managed at a local level, their condition is determined by the cumulative interactions of biophysical, social, economic and political structures and processes, operating across a range of spatial and temporal scales (Stringer et al., 2007). Biophysical factors such as climate, soil and hydrological patterns are superimposed with socio-political and economic structures and processes such as markets, technological changes, population demographic changes and human migration (UNEP, 1997). Some of these variables move slowly and operate over long time frames, while others are more rapid (Carpenter and Turner, 2000). The lived experience of land and soil degradation becomes apparent at the local scale (Warren, 2002), where it is experienced as a creeping phenomenon (Braimoh and Vlek, 2008), with the populations most acutely dependent on the natural resource base for their survival (often the poor and marginalised) being the most vulnerable to its effects (Stringer et al., 2009).

While the land and soil resource being degraded relates to national sovereignty concerns, the indirect impacts of degradation transcend village, district and national boundaries and affect food prices, food security and ecosystem service provision in downstream locations, far away from the site of degradation. This differs from environmental challenges that involve common property resources that naturally directly affect everybody (e.g. ozone depletion). However, these complex multi-scale linkages present a clear need to frame land and soil degradation as global issues that require international recognition – particularly in driving investment in funding, technology transfer and capacity building to tackle the land and soil challenge (Lambin et al., 2002) – and because continued land and soil degradation threatens our common food security. An international approach is further pertinent because land and soil degradation are thought to be increasing globally in both severity and extent (Bai et al., 2008) and cooperation across national borders is vital if conflicts over land, soil and associated resources such as water, are to be avoided. In the absence of the sustainable use and management of land and soil resources, global sustainable development and environmental sustainability are at risk.

This paper provides an overview of the current state-of-the-art knowledge on global land and soil degradation. It begins by noting the importance of environmental governance in delivering a sustainable land and soil legacy to future generations. It then explores four different types of land and soil degradation, drawing on examples from agriculture, forestry, mining, energy and water sectors, examining the interactions between different biophysical and socio-economic factors that can lead to degradation in the context of a globalised economy. Next, it examines the challenges associated with monitoring and assessing degradation and sustainable land and soil management, particularly in relation to developing effective, globally-appropriate approaches and indicators, reflecting upon the challenges associated with elucidating trends and dynamics. It argues that a global approach is needed to advance land and soil sustainability and explores recent efforts to promote a new Sustainable Development Goal (SDG) associated with zero net land degradation. The paper concludes by setting out key areas that need further attention from scientists and policymakers, to which Global Soil Week can usefully contribute.

2. Structures and processes framing land and soil degradation

The United Nations Convention to Combat Desertification (UNCCD) defines land as “the terrestrial bio-productive system that comprises soil, vegetation, other biota and the ecological and hydrological processes that operate within the system”. Often, land degradation is the result of damage to, or loss of, the soil. The condition of the world’s land and soil today is closely tied to their management under recent, as well as current, governance systems and environmental and climatic conditions. For example, during the Western colonial period, agricultural advisers in Africa promoted practices such as the burning or removal of crop residues from fields. Over time, this damaged the soil structure, caused organic matter and biota to decline, and ultimately, reduced productivity. At the same time, as commercial farming spread, colonial governments concentrated indigenous populations into reserves or homelands, often in areas where the soil or topography were less conducive to successful agricultural production. This forced migration meant that when independence was attained, the better arable land in most countries was largely farmed by an expatriate minority of commercial farmers (Fowler and Rockstrom, 2001), leaving the poorest and most natural resource-dependent populations in the areas least able to support their subsistence.

Similarly, in post-Socialist Europe and Central Asia, previously centralized governance systems played a role in shaping the quality of the land and soil resource of today. Under socialist ideologies, land was thought to have no intrinsic value but to serve human needs (Mazurski, 1991). This resulted in the widespread exhaustion, pollution and contamination of soil. For example, in 1970s Kazakhstan, massive state subsidies, inappropriate, inefficient irrigation, and the application of vast amounts of poor-quality pesticides and fertilisers, supported cotton and wheat production in areas largely unsuitable for these crops. The result of this was widespread soil and water contamination (Spoor, 1998). The pursuit of unrealistic, top-down production targets set by the centralised government caused huge environmental problems. People living in the Aral Sea region are still dealing with the impacts of past environmental governance approaches today (Scrieciu and Stringer, 2008).

Environmental governance and decision making in the past therefore shaped the land cover and land use patterns of the present. With the world’s population of 7 billion people today and a projected population of 9 billion by 2050, all dependent on healthy land and soil for their food production, it is vital to critically reflect upon our attitudes today, if soil productivity is required to continue into the future. To move towards the goal of sustainable development requires our legacy to future generations to take the form of a sustainable, rather than a degraded, land and soil resource.

Land and soil degradation can take four main forms: 1) water erosion; 2) wind erosion; 3) chemical degradation; and 4) physical degradation (Oldeman et al., 1991) (Figure 1). Each form of land and soil degradation, occurring both individually and in combination with the other forms of degradation, can result in the loss or damage to key ecosystem functions and processes, including nutrient cycling, primary production, climate, disease and water regulation, and food, fuel and fibre provision (MA, 2005). Maintaining healthy land and soil is therefore vital to sustain food production. In the remainder of this section, each of the four forms of degradation is discussed, outlining their links to the broader structures and processes that act to couple human and environmental systems (Lebel et al., 2006), and which, through their interaction, can result in degradation.

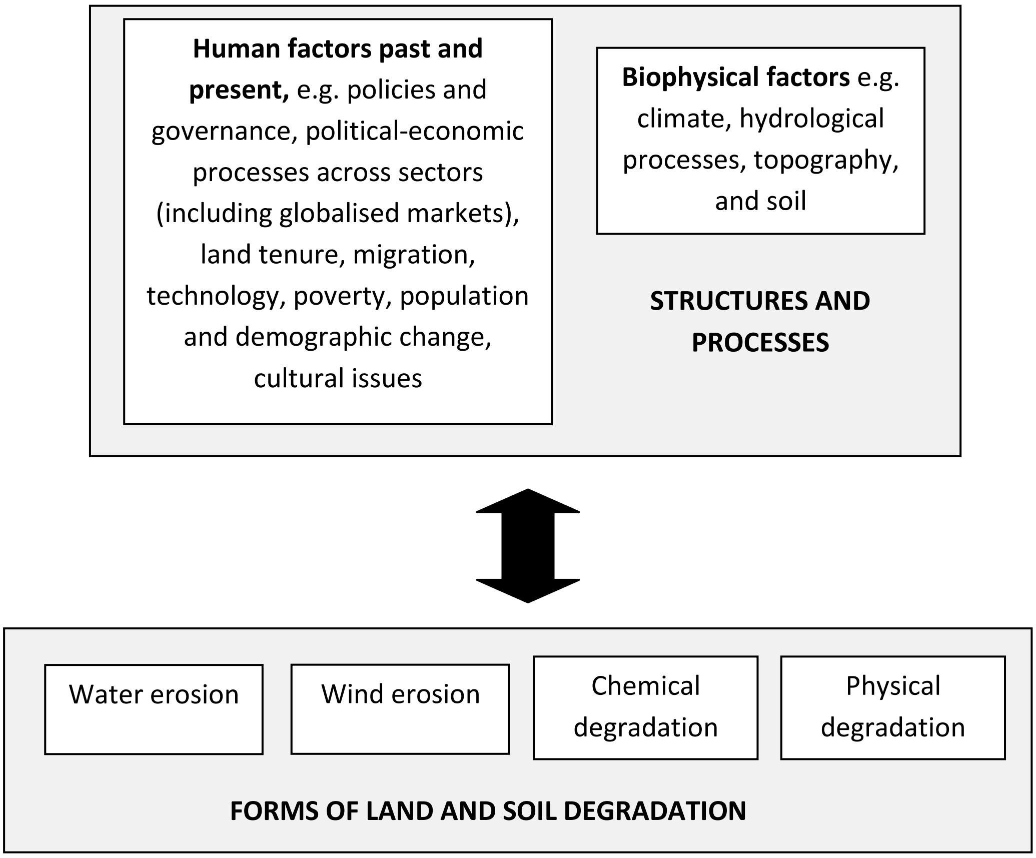

Figure 1: Classes of land and soil degradation and structures and processes that can combine to result in degradation

2.1 Water and wind erosion

Water and wind erosion can be attributed to both natural biophysical and human causes. Erosion can remove the most fertile topsoil, causing soil productivity to decline. In locations where soil is shallow and land is sloping, such as in the Ethiopian highlands (Tamene and Vlek, 2007), this can lead to an irreversible loss of soil and hence land degradation. Often, increases in water and wind erosion result from land use changes that alter the land's vegetative cover, for example, when forests are converted to agricultural land. This can disrupt soil functions and the links between soil and other ecosystem components. For example, in China's Loess Plateau, extensive deforestation attributed largely to population increases over the past century, left the land surface bare. This led to problems associated with rill and gully erosion as the rain washed down the steep slopes, taking the soil with it (Zheng et al., 2005). This not only eroded the soil but caused the sedimentation of water courses (Feng et al., 2010). Under conditions of climate change, extreme events including heavy rainfall and drought are likely to become more commonplace in some locations, with important impacts on soil erosion. For example, recent droughts in the Horn of Africa caused people migrate to other, less affected areas, in order to access sufficient food and water. In locations in receipt of migrants, large-scale deforestation has taken place, driven by demand for charcoal. This has left the land exposed and prone to erosion (Terefe, 2012). Soil erosion is not however, only a developing world problem. In the croplands of the United States of America, post-harvest farming practices cause land cover changes, which play a key role in determining the extent of dust entrainment and wind erosion. Practices such as ploughing, mowing and levelling beds can all increase wind erosion and dust emissions, while the planting of windbreaks, use of cover crops and leaving plant residues in the field after harvesting can all reduce the risk of erosion (Nordstrom and Hotta, 2004).

2.2 Chemical degradation

Chemical degradation can encompass the loss of nutrients and organic matter, salinisation, acidification and pollution. Increasingly, global analyses are recognising that such less visible changes in soil properties are critical in affecting crop yields (Mueller et al., 2012) and that monitoring systems need to evolve to focus on key parameters such as soil organic carbon content and integrated nutrient management approaches. Nutrient and organic matter losses can have an important influence on the soil's structure, stability, water holding capacity, ecology and biodiversity.

Market demands for particular produce can lead to unsustainable land management practices, which can play an important role in affecting soil nutrients and organic matter content, particularly when the practices pursued fail to return nutrients to the soil. Intensive agriculture can lead to organic matter reductions of up to 50% following several decades of cropping (Zingore et al., 2007). For example, consumer demands for soy, coupled with the deregulation of several markets for agricultural goods and services, led Argentina to become the third largest soy producer in the world in the 1990s (Trigo et al., 2009). A global rise in soy prices caused the agricultural frontier to expand in order to keep up with production demands. This led to widespread deforestation of native woodland and land cover shifts that altered the role and function of soil. On farms where soybean cultivation followed the production of wheat or maize, practices involved burning the crop remains to clear the fields quickly and plant the soybean. This caused extensive losses of soil organic matter, undermining productivity to the extent that in the 1990s, soil degradation was estimated to have affected 60 percent of the farmland of Argentina's Carcaraña River basin (Trigo et al., 2009). At the same time, the expansion of soybean cultivation into new areas triggered controversy over land and property rights (Masuda and Goldsmith, 2009).

In some parts of the world, high levels of poverty can mean that land users cannot afford to purchase inputs such as fertilisers that typically replenish soil nutrients. For example, Vitousek et al. (2009) sampled the farms of 90 smallholders in the Siaya District of Kenya and found that the nitrogen inputs from the fertilizers they could afford to provide were less than the amount removed in grain and crop remains. In other cases, a lack of rural farm labour (due to rural-urban migration and health problems such as HIV-AIDS) has led to the collapse of traditional integrated (organic and inorganic) nutrient management approaches in which livestock manure, crop residues and household compost provide organic inputs to arable fields. In northern South Africa, Dougill et al. (2002) showed how such changes led to reliance on inorganic fertilisers, which resulted in the acidification of the region's sandy soil, to the extent that maize yields were significantly reduced and major remediation was required through lime and manure treatments.

For many rural poor, security of land tenure may be lacking to the extent that land users do not have sufficient incentive to invest in soil inputs. This is particularly so when insecure tenure results in an absence of attachment to a particular location; a common problem in countries where tenure uncertainties lead to the practice of shifting cultivation (Whiteside, 1998). Situations such as this can lead to a downward spiral of poverty and degradation

(Quan and Toulmin, 2000), in which those most dependent on the land and soil for their subsistence end up degrading the soil further, precisely in order to survive over the short term.

Soil degradation through pollution and acidification can be local or diffuse. Diffuse pollution is caused by contaminants that are far from the source. One example of diffuse pollution are SO_x and NO_x emissions from industry and transport, which can cause soil acidification and threaten vegetation and water quality in locations away from the original emissions site, in some cases across national borders. Diffuse pollution is widely documented in the Sudbury region of Ontario, Canada, where mining and ore smelting has released more than 100 million tons of SO_2 over the past century, causing elevated concentrations of metal in the soil, acidification and damage to forests (Narendrula et al., 2012). Global demand for copper is continuing to drive price increases, compelling countries such as Zambia and the Democratic Republic of the Congo to construct huge copper mines to exploit their reserves of this resource. At the same time, mining activities have caused these countries to fall within the ten most polluted areas worldwide (Banza et al., 2009).

Salinisation occurs when the concentration of water soluble salts in the soil increases. This can happen due to natural processes, with salts being transported from saline geological deposits or groundwater, or due to human processes, particularly the use of inappropriate irrigation. The Mekong Delta region in Vietnam is one area where salinisation of vast expanses of land has taken place, largely due to saline intrusion and the irrigation of fields with saline water to enable shrimp farming. Soil salinisation has had important detrimental effects on rice production, as well as reducing drinking water availability (Minh, 2000). In Western Australia, abundant natural salts within the soil, combined with the clearance of native vegetation, has caused critical hydrological changes and extensive salinisation, with groundwater levels rising by more than 30 m. More than 1.8 million ha (9.4% of cleared farmland in Western Australia) is salt affected, imposing severe restrictions on productivity and, in some cases, has caused land abandonment (George et al., 1997).

2.3 Physical degradation

Physical degradation can include compaction, sealing/crusting, water logging and subsidence. Soil sealing is often a consequence of urban development and infrastructure construction, as the soil surface is covered with impervious materials such as concrete, plastics, glass and metal. The extent to which sealing takes place links closely to the type of land use and the population density. Global population growth, migration and increasing rates of urbanisation throughout the world, suggest that sealing is a trend that will continue into the future. In Europe, around 9% of the total land area is covered by an impermeable material (Scalenghe and Marsan, 2009), while in the urban areas of Germany, 52% of the soil is sealed (EEA, 2006). This has knock-on effects for the role of soil in energy transfer and temperature regulation processes, water flows, and gas diffusion (including the propensity of soil to act as a carbon sink). It also affects the soil biota.

In agricultural areas, soil compaction due to the use of heavy machinery can alter its drainage and physical properties as a result of reduced soil porosity, which can subsequently restrict the movement of water and gases through the soil. For example, the advent of technologies such as the mouldboard plough in the United States in around 1850 set in motion a long-term trend that damaged the soil structure and increased the soil's susceptibility to crusting, compaction and erosion (Lal et al., 2007). Similarly, in pastoral areas, as grazing regimes have become less extensive and more sedentary due to policy restrictions and land tenure controls, soil compaction has ensued, together with other ecosystem changes such as lower pasture palatability, reduced infiltration and ultimately, land and soil degradation (Niamir-Fuller, 2005).

Loss of soil biodiversity cross-cuts many of the different types of land degradation as soil biota play a vital role in several ecosystem processes and functions, underpinning food and fibre production as well as helping to regulate the climate and purify water. The spatial distribution of soil biota, along with their heterogeneity, has an important influence on soil carbon turnover rates and trace gas production (Schmidt et al., 2010). In dryland areas, biological soil crusts form an integral biotic component and have a dominant influence over key functions such as carbon and nitrogen cycling, soil stabilisation and infiltration (Whitford, 2002). The IPCC (2007) notes that warming promotes a significant decrease in the richness and diversity of biological soil crust communities, accompanied by key shifts in species compositions. Such changes could reduce or even reverse the positive effects of these soil organisms on multiple ecosystem functions (Maestre et al., 2012).

2.4 Synthesis of land and soil degradation drivers

As shown in Figure 1 and demonstrated by the examples from around the world linked to each type of degradation, the propensity for land and soil to become degraded depends on the interaction of a number of biophysical and human factors. Human action operating across different economic sectors (agriculture, forestry, energy, mining and water), in combination with contextual biophysical environmental factors, can cause and exacerbate land and soil degradation. While global monitoring and assessment attempts have sought to measure how much degradation is taking place (see section 3), it remains difficult to quantify and qualify the exact combination of interacting factors that drive degradation.

There is an urgent need for more in-depth research that spans scales from the local to the national, regional and international, in order to further identify particular syndromes or pathways that result in a greater risk of degradation (Geist and Lambin, 2004) and the ways in which they can be mitigated into the future. In many of the cases outlined above, the costs of degradation are borne at the local scale by the poorest and most marginalised communities (Broad, 1994), and yet they are driven by broader scale political and economic processes. This presents a clear need for the total economic value of land and soil resources to be assessed and the external costs of degradation to be evaluated. This is particularly so in areas where land is communally managed, because unlike privately owned land, the use of an area by one person does not preclude its use by others. This can lead some land users to take more than their fair share (e.g. grazing an excessive number of cattle in a particular location), causing a 'tragedy of the commons' where inadequate institutional regulation is in place. At the same time, the discount rate to assess the present value of soil functions and services is too high, causing decision makers to support policies that fail to maximise benefits over the long term (OSLO, 2011). Short-term decision making at a range of scales can therefore be considered an additional cause of degradation.

3. Challenges in monitoring, measuring and assessing the status and trends of degradation

Despite the diverse forms that land and soil degradation can take and the range of different factors that combine to culminate in degradation, several attempts have been made to identify the current status and trends. Certain environmental and socio-economic conditions mean that some parts of the world are more vulnerable and at risk from land and soil degradation than others. Drylands (arid, semi-arid and dry subhumid areas) are one example of a hotspot where land and populations are particularly vulnerable, both at present and into the future (Middleton et al., 2011). Indeed, desertification (land degradation in drylands) has been ranked amongst the most urgent global environmental challenges (MA, 2005).

Estimates of the extent of land and soil degradation are varied, ranging from 0.6-1.2 billion ha of the world's drylands (MA, 2005), to 3.5 billion ha of degraded soil globally (Oldeman et al., 1991). Such varying figures make it highly challenging for: (a) scientists to communicate the magnitude of the degradation problem; and (b) policymakers and other stakeholders to know how urgently action needs to be taken. The outcomes of such assessments are further complicated, as they each use different assessment methods, measure different variables, and operate at different scales (both temporal and spatial), with some focusing on particular bounded systems such as drylands. This means that the outcomes from different assessments cannot be usefully compared. Despite these issues, in the context of other sustainable development challenges such as population growth, climate change, biodiversity loss, assessments nevertheless demonstrate that land and soil degradation is a key issue and that it is likely to worsen into the future unless timely action is taken.

The above measurement and comparability challenges notwithstanding, two notable assessment efforts since the 1990s are GLASOD and LADA/GLADA. GLASOD (the Global Assessment of Human-Induced Soil Degradation) provides a global map of soil degradation at a 1:10 000 000 scale (Oldeman et al., 1991), based largely on (somewhat subjective) expert opinions on the type, extent, degree, rate and causes of degradation (Oldeman and van Lynden, 2001). GLASOD considers four main causes: (i) agriculture; (ii) deforestation; (iii) overgrazing; and (iv) industrial pollution. Although this study was valuable because it raised awareness of the importance of land and soil, it is now rather outdated and soil degradation is thought to have worsened since 1991. GLASOD also did not test the links between degradation status and the social and economic impacts experienced (Sonneveld and Dent, 2009), and ignored the human structures and processes that drive the causes.

LADA (Land Degradation Assessment in Drylands) and GLADA (Global Assessment of Land Degradation and Improvement) represent more recent assessment efforts. These follow on from GLASOD across global, national and sub-national scales to identify the status and trends of land degradation in drylands, degradation hotspots and bright spots (both actual and potential) and find that 24% of the global land area has been degrading over the past 25 years. This contrasts with the 15% of degraded soil (not land) identified in GLASOD. However, interactions between the various variables that are monitored are not considered (Tengberg and Batt Torheim, 2007). Bai et al. (2008) suggest the need for the cautious use of GLADA results for a number of reasons. Importantly, the methodological approaches employed mean that GLADA finds it more difficult to identify degradation in arid areas compared with more humid and temperate locations, possibly underestimating the extent of desertification.

More recently, the Millennium Ecosystem Assessment (MA, 2005) sought to systematise the conditions and trends of existing assessments with a view to showing how ecosystems can facilitate poverty reduction, evaluating a range of different responses. Within the MA, land and soil issues are considered through an ecosystem approach, which focuses on the status and trends of the ecosystem services that land and soil provide. The assessment concludes that >60% of ecosystem services have been degraded. However, it provides limited information on the specific status of soil. It nevertheless gives particular consideration to desertification. Drylands cover 41% of the planet's land area and are inhabited by more than 2 billion people (Middleton et al., 2011). The MA suggests with medium certainty that 10-20% of drylands are already degraded, with a much larger area under threat from desertification in the future. It suggests that desertification and ecosystem service degradation (including soil degradation) in drylands are a key threat to human development, particularly in the context of projected climatic changes.

Tracking trends in desertification, as well as land and soil degradation, and their links to different human and biophysical drivers is especially difficult (Eswaran et al., 2001), particularly if the information needs of stakeholders as diverse as policy makers, scientists, land managers and society at large are to be met (Vogt et al., 2011). The kind of authoritative and consensual assessments that are needed do not yet exist (UNCCD, 2011). Within the coupled human-ecological system, it is necessary to identify critical variables that target both human and ecological system components. Monitoring needs to draw on indicators that measure both 'slow' and 'fast' human and biophysical variables (Reynolds et al., 2011). This is likely to require a combination of both locally- and nationally-specific indicators across sectors, as well as internationally agreed, standardized global indicators. A meaningful baseline also needs to be identified, from which the status and trends in degradation can be assessed (Reed et al., 2011). A baseline and indicators need to be agreed upon and used, with appropriate monitoring and reporting systems established in order to track the direction of degradation. Decisions on these aspects need to take into consideration all necessary spatial scales and permit comparability (Vogt et al., 2011), linking tools and technologies such as remote sensing with participatory ground truthing. Initiatives such as Global Soil Week, the Global Soil Partnership and the UNCCD could play a key role in conveying the urgency with which indicators and baselines need to be established.

4. Developing the legacy of a degradation neutral world to future generations: moving towards land and soil sustainability during Global Soil Week

The ability to upscale to develop an effective global approach for monitoring, assessment and management of land and soil degradation is particularly pertinent in the context of global aspirations to move towards Zero Net Land Degradation (ZNLD). ZNLD efforts are being driven forward by the United Nations Convention to Combat Desertification (UNCCD), the main objective of which is to address desertification, land degradation and mitigate the effects of drought. Through its ten-year strategic plan (2008-2018), the UNCCD also seeks to promote ecosystem functioning, improve the well-being of ecosystem users and generate global benefits.

The concept of a ZNLD world was initially discussed by the UN General Assembly in 2011 and is mentioned in the Changwon Initiative that emerged at the UNCCD COP 11, held in October 2011. The idea was formally launched within the framework of the Rio+20 Sustainable Development Conference held in 2012, during which, the international community discussed the kinds of policy targets that should follow the Millennium Development Goals, post-2015. The Rio+20 Outcome document (paragraph 206) ‘recognizes the need for urgent action to reverse land degradation’. It further notes that, ‘in view of this, we will strive to achieve a land degradation neutral world in the context of sustainable development’.

Articulation of a set of Sustainable Development Goals for post-2015 provides a valuable opportunity to concretely establish the goal of a ZNLD world within an international policy framework. Beyond agreement on the wording of the goal to determine what exactly a ZNLD world means, and the targets this demands, an institutional framework will need to be established (or entrusted to an existing mechanism), clearly outlining the roles and responsibilities of different stakeholders. Processes and mechanisms for measuring progress towards a ZNLD SDG will need to be established, paying particular attention to concepts such as leakage– where e.g. degradation avoided in one location is merely displaced to another place– which has caused difficulties in relation to other agreements like the UNFCCC. Related to leakage, clear baselines are required and need to be incorporated into any global level goal or agreement.

Issues such as how national progress towards such a goal can be monitored given the complex, multi-scale drivers of degradation; how degradation in one place may be compensated by rehabilitation in another; how different time frames for the regenerative effects of rehabilitation measures to improve soil quality and health will be considered; and how degradation leakage can be avoided, all remain to be determined. Alternative policy options such as adding a protocol on global land and soil degradation to the UNCCD require careful, critical evaluation, alongside the ways in which this could interface with other advances such as the Global Soil Partnership and the work of scientific networks engaged in efforts to tackle the sustainability challenges linked to land and soil. Solving these challenges will require inputs from the scientific community, working across disciplines, as well as the political arena, working across sectors. Global Soil Week provides a useful platform from which to advance these discussions, helping to answer these questions and proposing important ways forward for the development of internationally agreed frameworks.

Achieving ZNLD at a global scale demands a combination of sustainable land use and land management practices (beyond the agricultural sector, including those linked to construction and industry). These need to prevent the occurrence of soil degradation in the first place, while rehabilitation and restoration strategies need to be enacted to bring already degraded land back into productive use. It requires attention to be paid to economic aspects, in particular, the identification of areas that should be prioritised for recovery and rehabilitation investments, as well as recognizing the costs associated with failure to pursue sustainable practices in degradation vulnerable hotspots such as drylands. This will mean balancing a range of different demands placed on the land and soil resource (e.g. food production, biodiversity conservation, carbon storage). It may require decisions to be made regarding land sparing versus land sharing – in which certain areas take priority in meeting basic demands for food (e.g. concentrating on high yielding practices in agricultural areas), while delineating and protecting other areas for different ecosystem service conservation and livelihood activities (Phalan et al., 2011; Green et al., 2005). Such approaches need to be developed through partnership and dialogue with other key multi-lateral environmental agreements, particularly the United Nations Framework Convention on Climate Change (UNFCCC) and Convention on Biological Diversity (CBD), in order to harness synergy in meeting the goals of these conventions. Land restoration activities in drylands, one of the most vulnerable systems, could help to deliver synergistic benefits in practice. Indeed, the Cancun Agreements (decision 1/COP.16) consider why, where and how outcomes of the UNFCCC can benefit land and soil issues.

5. Conclusions and discussion points

This paper has demonstrated that land and soil degradation often result from the interplay of broad scale biophysical and political-economic processes (both past and present), including short-term decision making across a range of scales. However, the costs of land and soil degradation and its impacts often are experienced at the local level by the poorest and most marginalised communities. Despite disagreement over the exact extent and rate of land and soil degradation, state-of-the-art scientific assessments all share common ground in that they demonstrate degradation to be a key human development issue, in need of urgent attention if the situation is not to worsen into the future.

Given the urgency of action required to address global land and soil degradation, the need for political support and action is vital. The current international regime that addresses land and soil issues remains weak, invisible and fragmented. While the economic evaluation of costs and benefits associated with action and inaction is currently being made through initiatives such as the Economics of Land Degradation initiative, which seeks to place a figure on the social and economic costs facing countries as a result of degradation, land and soil need to be mainstreamed into local, national and international policymaking (Akhtar-Schuster et al., 2011). Trade-offs over long, medium and short-term periods need to be evaluated by policymakers in order to realise the importance of investments in healthy soil now and the wider markets that can be targeted by such investments (e.g. carbon markets – see Stringer et al., 2012; Dougill et al., 2012). Global Soil Week is well positioned to draw political attention to these challenges. It also provides a unique and valuable platform to engage in discussions across the science-policy interface to drive forward solutions. The questions presented in Box 1 provide a useful starting point for discussions.

- How can the combinations of factors that result in land and soil degradation acting across scales be better quantified and qualified?
- Which slow and fast variables need to be measured at different scales and across the coupled biophysical-human system in order to deliver authoritative and consensual assessment of global land and soil degradation and sustainability trends?
- What is zero net land degradation?
- What is a land degradation neutral world?
- What targets does it require?
- What kind of institutional framework does it demand?
- Who are the key stakeholders and what are their roles and responsibilities?
- How can we measure progress towards zero net land degradation?
- What are the costs and benefits associated with a zero net land degradation world?
- How can degradation leakage be avoided?
- How can national progress be monitored and measured in view of the multi-scale factors that result in degradation?
- How can remediation measures be accounted for and valued when they deliver benefits over different time frames?
- Which areas should be prioritised for investment in remediation efforts?
- Beyond an SDG focused on zero net land degradation, what alternative and/or complementary policy options need to be considered?
- How can the concept of zero net land degradation harness synergy with the other Rio conventions and other (relevant) MEAs?

Box 1: Key discussion points and research questions to which Global Soil Week can contribute

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