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Achieving Zero Net Land Degradation: Challenges and opportunities

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ABSTRACT

Land degradation is extensive, covering approximately 23% of the globe's terrestrial area, increasing at an annual rate of 5–10 million ha, and affecting about 1.5 billion people globally. Such detrimental processes call for urgent and comprehensive action to halt land degradation. In this paper, we assess the causes and extent of land degradation around the world, followed by an outline of the various challenges in implementing a global Zero Net Land Degradation (ZNLD) policy. The concept of ZNLD proposes a scheme under which the extent of global degraded lands will decrease or at least, remain stable. To enable this type of scenario, the rate of global land degradation should not exceed that of land restoration. Restoration efforts should include not only croplands, rangelands, and woodlands, but also natural and semi-natural lands that do not generate direct economic revenues. The United Nations Convention to Combat Desertification (UNCCD) envisages achieving this target by 2030. Despite being seemingly ambitious, the target of ZNLD could be achieved if degraded lands are restored to a considerable extent and, at the same time, land-degrading management practices are replaced with ones that conserve soils. To enable effective implementation of these steps, it is necessary to formulate a ZNLD Protocol aimed at managing assessment actions and maintaining of supportive policies and regulations. Restoration projects could be financed through payments for improving ecosystem services, as well as other economic mechanisms. Achieving the target of land degradation neutrality would decrease the environmental footprint of agriculture, while supporting food security and sustaining human wellbeing.

1. Introduction

Land degradation is defined as the reduction of biological productivity and the decrease in the complexity of terrestrial ecosystems (Lal et al., 2012). Processes of land degradation occur in all climatic regions, with 'land' interpreted to include soils, vegetation, and water, and with the concept of 'degradation' implying adverse consequences for humanity and ecological systems (Conacher, 2009). Overall, land degradation affects about 1.5 billion people globally (Gnacadja, 2012b).

Among the above-mentioned 'land' components, the soil is a major source of terrestrial net primary productivity (NPP), the reservoir of the gene pool, the sink of atmospheric carbon, and the reservoir of plant nutrients (German Federal Environment Agency, 2011). Specific types of soil degradation include erosion caused by wind or water, and deterioration of the physical, chemical, and biological properties of soil (Lal et al., 2012). Degraded soils are less able to support vegetation production (Gisladottir and Stocking, 2005). Hence, vegetation is among the first elements to be adversely affected in degraded ecosystems. This loss of native vegetation directly threatens a range of ecosystem processes and services. Soil degradation has been caused by human activities (Conacher, 2009; Zalibekov, 2011), natural factors, or a combination of both (Gisladottir and Stocking, 2005).

Agricultural activities are a major cause of environmental change, altering land productivity, water cycles, drought patterns, the amount of greenhouse gases (GHGs) in the atmosphere (Stavi and Lal, 2013), and biodiversity. Specifically, land resources have come under increasing pressure from competing usages for agriculture, forestry, and pasture, as well as energy production and extraction of raw materials (UNCCD, 2012). Since land degradation processes reduce the rate of carbon sequestration and increase GHG emissions, it is less likely that GHG reduction targets will be met. Also, since land degradation results in loss of productivity, and hence reduced food provision, global food security targets will be

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missed if land degradation is not successfully addressed (Lal et al., 2012).

Despite being a global phenomenon, the degradation of land has occurred to a much greater extent in drylands, where land is highly vulnerable to degradation due to aridity and water scarcity, than in non-drylands (UNCCD, 2012). Home to 38% of the world's population (2.7 billion people), drylands make up 44% of the world's cultivated lands, and account for 50% of its livestock (Gnacadja, 2012b). Therefore, drylands are the key to supporting habitats, crops, and livestock that sustain most of the global population (UNCCD, 2012). On a global scale, Africa is the region most vulnerable to desertification processes; over 45% of Africa is affected by desertification, and of this area, 55% is at high, or very high, risk of further degradation. If this trend continues, two-thirds of Africa's arable land could be lost by 2025 (UNCCD, 2011b).

The percentage of the world land area prone to serious drought more than doubled between the 1970s and the early 2000s, and the world is facing the possibility of widespread droughts in the coming decades (Lee, 2011). Even though droughts occur globally with different intensities and frequencies, their impact depends on the level of social, economic, and environmental vulnerability in the affected area. Specifically, droughts impose threats to rural livelihoods in developing countries, including many countries in Africa and central Asia, where unfavorable biophysical conditions meet with weak socio-economic infrastructures (UNCCD, 2011a). Elsewhere, the recent extreme droughts affecting western Asia and Eastern Europe have caused wheat harvests to decline in Russia and Ukraine by approximately 33% and 19%, respectively, severely diminishing the worldwide wheat supply, and doubling global wheat prices in less than a year. Additionally, in some northern African and Middle Eastern countries, the steep rise in the cost of food has fueled political instability (Sternberg, 2011). For example, the extreme drought in the Eurasian steppe in 2010–2011 resulted in diminished global wheat stocks, and considerably increased wheat prices. Egypt, with its import-dependent wheat market, faced an immediate and steep rise in the price of wheat, causing economic dissatisfaction and social unrest among many of its citizens (Sternberg, 2012).

The growth of the human population and increasing demands for food, water, and energy are expected to dramatically augment pressure on lands (Conacher, 2009). By 2030, the demand for food is projected to grow by 50%, and that of water and energy by 40% each, compared to present levels (Gnacadja, 2012b). The exponential increase of human population calls for a sustainable development that would help meet these future food, water, and energy challenges in an integrated way, and which would ensure efficiency, build resilience, and support social inclusiveness (UNCCD, 2012).

The concept of Zero Net Land Degradation (ZNLD), or land degradation neutrality, was first formally mentioned in 2011, by the president of the United Nations Convention to Combat Desertification (Lee, 2011; UNCCD, 2011a). This concept encompasses two complementary mechanisms: appropriate management of currently non-degraded lands in ways that do not cause degradation, thus halting further loss, and at the same time, restoring already-degraded lands (Gnacadja, 2012b). If the continuing loss of fertile lands is offset by the restoration of already-degraded lands, and the annual rate of reclamation equals that of degradation, then a ZNLD is attained, and the area of global fertile land remains stable (Gnacadja, 2012b). According to this concept, the restoration efforts would ideally be in the same landscape, the same type of ecosystem, and would serve the same community where land degradation has occurred (Gnacadja, 2012a).

The UNCCD set a target of achieving ZNLD by 2030 (Lal et al., 2012). Thus far, however, the conceptual framework of the ZNLD remains unclear, as it includes only a general idea, excludes many relevant aspects, and lacks concrete steps for implementation. Specifically, the types of land-uses and management practices to be included under the ZNLD have not yet been fully addressed. For example, while it is clear that croplands, rangelands, and woodlands are directly addressed under the ZNLD, the restoration of degraded natural or semi-natural lands that do not generate direct economic revenues has not been covered under this framework. Also, the specific means and practices for land conservation and restoration have not been thoroughly discussed under the ZNLD concept. Therefore, the objective of this study is to highlight some of the aspects that are either obscure, or have not been clearly addressed under the ZNLD conception. In addition, this study addresses the urgent need for policy, management, regulations, and funding of projects, aimed at facilitating the monitoring of degradation processes and the restoration of degraded lands.

2. Global land and soil degradation

2.1. Types of soil degradation

In the early-1990s, the extent of all degraded lands encompassed a total of 36×10^8 ha globally (Dregne and Chou, 1994). The main types of soil degradation, including water erosion, wind erosion, physical degradation, and chemical degradation, encompassed, at that time a land area of 10.9×10^8 ha, 5.5×10^8 ha, 2.4×10^8 ha, and 0.8×10^8 ha, respectively (Oldeman, 1994). Recent estimations of land degradation indicate that 3.5 billion ha – 23% of Earth's land area – have been affected by some type and severity of degradation, the annual rate of which is estimated at 5 to 10 million ha (Lal, 2012).

Over and above the adverse effects of numerous other processes, accelerated erosion is of special importance. Simulations of historical changes that tracked potential soil erosion from 1901 to 1980, revealed an increasing trend during this period. Such a trend has been found in all continents except Europe. Overall, human activity has increased soil erosion in most parts of the world to rates ranging between 8 and 90%. Globally, soil erosion has increased during this period by approximately 60% due to human activity (Yang et al., 2003). The global average value of potential erosion at the beginning of the 21st century was estimated at 10.2 ton ha^{-1} $year^{-1}$, and global loss of soil through erosional processes has been estimated at ranging between 24 (Lee, 2011) to 75 billion tons of fertile soil (Gnacadja, 2012b).

Salinization and sodification of soils are also widespread, occurring in all climatic regions, and are caused by natural conditions, human activities, or a combination of the two (European Soil Portal, 2009). Most human-caused soil salinization and sodification is found in croplands and results from the use of saline underground water for irrigation and the utilization of flood irrigation in the valleys of large river basins. In addition, salinization also occurs in the soils of coastal aquifers and of dryland farming systems due to saline seepage. Altogether, approximately one billion ha of land have saline or sodic soils (Squires and Glenn, 2010).

Soil pollution is also widespread. Sources of pollution can vary, including contaminants from households, agriculture, and industry. Contaminants encompass several types, such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), and dioxins (Turner, 2009). Specific examples for agriculture-derived pollution are the contamination of surface water and groundwater with nutrients and chemicals; the emission of substances, such as ammonia and particulates into the air; and the pollution of soils with remnants of fertilizers, pesticides, and herbicides (Grossman, 2007). Soil contamination risks include plants absorbing contaminants through the soil; groundwater becoming contaminated as it

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