**Land Restoration and Challenges in Land Degradation Mitigation**

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The restoration of degraded lands is a vital undertaking to enhance agricultural productivity and improve environmental quality. In general, lightly degraded soils can be effectively improved through practices such as crop rotation and minimum tillage, among other farm techniques. However, the restoration of more severely degraded soils poses significant difficulties. Moderately damaged land requires substantial resources beyond what an average farmer can afford for restoration. While changes in soil conservation practices can slow down land degradation, they may not fully restore soil fertility. Addressing such lands will necessitate national programs and major structural changes, such as draining and contour banks. Views on land degradation have given rise to two distinct schools of thought. One school views land degradation as a serious global threat, posing significant challenges to biomass productivity and environmental quality. This viewpoint is primarily supported by ecologists, soil scientists, and agronomists. On the other hand, the second school, primarily comprising economists, questions the severity of land degradation, arguing that market forces should have addressed the issue if it were genuinely severe. Supporters of this perspective argue that land managers, including farmers, have a vested interest in their land and would not allow it to degrade to the point that it harms their profits. Various factors contribute to the ongoing debate on land degradation:

**Definition:** The presence of numerous terms and definitions, such as soil degradation, land degradation, and desertification, leads to confusion, misunderstanding, and misinterpretation. While there is a clear distinction between 'soil' and 'land,' the terms 'land degradation' and 'desertification' lack a clear demarcation. Desertification, typically associated with arid, semi-arid, and sub-humid regions due to human activities, might also occur in temperate humid and humid tropical regions. Standardizing the terminology and developing a precise, objective, and unambiguous definition accepted by all disciplines is imperative.

**Land-Vegetation Relationships:** The term 'vegetation degradation' adds further confusion, as it may imply reductions in biomass, species diversity, or nutritional value for livestock and wildlife. Establishing distinct criteria for evaluating vegetation degradation is necessary.

**Methods of Assessment of Land Degradation:** Global assessment of land degradation is complex, involving a wide range of methods. Consequently, data generated by different methods are not directly comparable. Many statistics refer to the risks of degradation or desertification based on climatic factors and land use rather than the actual present state of the land. The variation in estimates due to different methods and criteria highlights the need for uniform criteria and standardized assessment methods.

**Land Degradation and Productivity:** Existing statistics on land degradation often lack a clear cause-effect relationship between degradation severity and productivity. Designation of different classes of land degradation (e.g., low, moderate, high) typically relies on land properties rather than their impact on productivity. Assessing the productivity effects of land degradation is challenging due to the multitude of variables involved. Global estimates of the impact of land degradation on productivity face difficulties and uncertainties. For instance, data from China showed that despite significant differences in cumulative soil loss and water runoff, there were no discernible differences in corn yield. Similar inferences apply to rice yield in Thailand. Assessing the productivity effects of land degradation requires a comprehensive understanding of the processes involved in the soil-plant-atmosphere continuum, heavily influenced by land use and management practices.

The issues and challenges related to land degradation require comprehensive solutions and collaborative efforts from various stakeholders. Let's explore some of the key points highlighted in the discussion:

**Is land degradation inevitable?** Understanding the factors that contribute to land degradation can help identify effective strategies to prevent and mitigate its impact. While some degree of degradation may occur naturally, human activities significantly accelerate the process. Implementing sustainable land management practices can help reduce the extent and severity of land degradation.

**Adequate early warning indicators of land degradation:** Developing reliable and timely early warning indicators is essential to detect and respond to land degradation promptly. Monitoring changes in soil health, vegetation cover, water quality, and land use can provide valuable insights for early intervention.

**Societal responsibility of soil scientists:** Soil scientists have a societal responsibility to communicate the consequences of declining soil quality resulting from human-induced degradation. They can advocate for sustainable land management practices and collaborate with policymakers to incorporate scientific evidence into decision-making processes.

**Participation of soil scientists in public policy:** Soil scientists should actively engage with policymakers and participate in the formulation of public policies related to land use, agriculture, and environmental conservation. Providing expert insights can lead to evidence-based policies for sustainable land management.

**International collaboration for local actions:** Recognizing that local actions have global impacts is essential in addressing land degradation. International collaboration can facilitate knowledge exchange, capacity building, and sharing of best practices, leading to more effective land restoration efforts.

**Economics of land degradation:** Analyzing the economic implications of land degradation is crucial for understanding the true cost and benefits of sustainable land management practices. Identifying economic incentives for conservation can encourage land users to adopt environmentally friendly practices.

**Link between land degradation and human/animal health:** Investigating the link between land degradation and human/animal health can provide evidence for the importance of sustainable land management in safeguarding public well-being.

**Quantifying resource consumption rates:** Developing methods to quantify resource consumption rates in agrarian economies can help assess the environmental impact of land degradation and inform resource management strategies.

**Quantifying the aesthetic value of land:** Assessing the aesthetic value of land can contribute to raising awareness about the importance of preserving natural landscapes and ecosystems.

**Creating awareness of land degradation:** Raising awareness among society and political leaders is vital to garner support for initiatives aimed at reducing land degradation. Education, outreach programs, and media campaigns can play a significant role in creating greater awareness. In addressing these issues, a three-step approach involving assessment, monitoring, and application of mitigating technologies is crucial. Soil scientists play a critical role in these steps, from understanding the spatial distribution and rates of degradation to collaborating with other disciplines to develop effective mitigation strategies. To preserve this non-renewable resource, it is imperative to recognize the significance of soils in sustaining agriculture and society as a whole. New paradigms for managing soil resources should be developed, taking into account contemporary environmental challenges and the need for sustainable practices. Allocating adequate research and development funds for soil conservation and fostering a global commitment to soil protection are vital for a sustainable future.

Land degradation results from mismanagement of land and thus deals with two interlocking, complex systems: the natural ecosystem and the human social system. Interactions between the two systems determine the success or failure of resource management programs. The avert the catastrophe resulting from land degradation, which threatens many parts of the world, the following concepts are relevant:

• Environment and agriculture are intrinsically linked and research and development must address both of them.

• Land degradation is as much a socioeconomic problem as it is a biophysical problem.

• Land degradation and economic growth or lack of it (poverty) are intractably linked; (people living in the lower part of the poverty spiral are in a weak position to provide the stewardship necessary to sustain the resource base. As a consequence, they move further down the poverty spiral- a vicious cycle is set in motion).

• Implementation of mitigation research to manage land degradation can only succeed if land users have control and commitment to maintain the quality of the resources.

• The focus of agricultural research should shift from increasing productivity to enhancing sustainability, recognizing that land degradation caused by agriculture can be minimized and made compatible with the environment.

• Land use must match land quality; appropriate national policies should be implemented to ensure this occurs to reduce land degradation; (a framework for evaluation of sustainable land management [Dumanski et al., 1992] is a powerful tool to assess such discrepancies and assure sustainability).

The thrust of a new agenda for resource assessment and monitoring with respect to land degradation (include desertification), has several components. It must be stressed that any research and development activity should be in the larger context of the ecosystem. Components of a national strategy to address land degradation (and desertification) comprise:

• Studies on long-term water needs (quality and quantity)

• A network of monitoring sites to detect changes in natural resource conditions.

• Working with farmers by understanding and incorporating indigenous knowledge.

• Including land degradation aspects in research on cropping and farming systems, and soil and water management.

• Convincing decision-makers that climate change, desertification, quality of life, and sustainability are all interlinked and addressing one helps the other.

• Initiating research on a new paradigm that is holistic and focuses on these issues.

A ‘scale-sensitive information system’ or database on land degradation must be made available for the vertical network of decision-makers to enable them to make effective policies concerning the use and management of resources. Decision-makers at all levels of society should be able to participate in the design and implementation of any tool that affects the social, economic, and ecological well-being. This ensures successful implementation of the program.

Important challenges are:

• To mobilize the scientific community to mount an integrated programme for methods, standards, data collection and research networks for assessment and monitoring of soil and land degradation.

• To develop land use models that incorporate both natural and human-induced factors that contribute to land degradation and that could be used for land use planning and management.

• To develop information systems that link environmental monitoring, accounting, and impact assessment to land degradation.

• To help develop policies that encourage sustainable land use and management and assist in the greater use of land resource information for sustainable agriculture.

• To develop economic instruments for the assessment of the land degradation and encourage the stainable use of land resources.

• To rationalize the wide range of terminology and definitions with different meanings among different disciplines associated with land degradation.

• To standardize methods of assessment of the extent of land degradation.

• To develop non-uniform criteria for assessing the severity of land degradation.

• To overcome the difficulty in evaluating the on-farm economic impact of land degradation on productivity.

Addressing land degradation is a complex task that requires a holistic approach, considering both the natural ecosystem and the human social system. The following concepts are crucial for averting the catastrophe resulting from land degradation:

**Linking environment and agriculture:** Research and development efforts must address both environmental and agricultural aspects, recognizing their intrinsic interdependence.

**Socioeconomic nature of land degradation:** Land degradation is not solely a biophysical problem; it is equally a socioeconomic challenge that needs to be addressed to achieve sustainable land management.

**Link between land degradation and poverty:** Land degradation and economic growth or poverty are closely linked. Poverty can hinder proper resource stewardship, leading to a vicious cycle of degradation and poverty.

**Community involvement and commitment:** Mitigation research for land degradation can only succeed when land users have control and commitment to maintain resource quality.

Shifting focus from productivity to sustainability: Agricultural research should prioritize enhancing sustainability over mere productivity, ensuring that land degradation caused by agriculture is minimized and environmentally compatible.

**Land use matching land quality:** National policies should be implemented to ensure appropriate land use matching the land quality, thereby reducing land degradation.

The new agenda for resource assessment and monitoring related to land degradation should consider the following components:

* Studying long-term water needs, quality, and quantity.
* Establishing a network of monitoring sites to detect changes in natural resource conditions.
* Incorporating indigenous knowledge and involving farmers in research and development.
* Including land degradation aspects in research on cropping, farming systems, soil, and water management.
* Promoting the understanding that climate change, desertification, quality of life, and sustainability are interconnected, addressing one can positively impact the others.
* To ensure successful implementation, decision-makers at all levels of society should be engaged in the design and execution of programs addressing social, economic, and ecological well-being.

The important challenges in addressing land degradation include:

* Mobilizing the scientific community for an integrated program for assessment and monitoring methods, data collection, and research networks.
* Developing land use models that consider natural and human-induced factors contributing to land degradation for effective planning and management.
* Establishing information systems that connect environmental monitoring, accounting, and impact assessment to land degradation.
* Formulating policies that encourage sustainable land use and management, utilizing land resource information for sustainable agriculture.
* Developing economic instruments to assess land degradation and encourage sustainable land use.
* Standardizing terminology, definitions, and methods for assessing the extent and severity of land degradation.
* Addressing difficulties in evaluating the on-farm economic impact of land degradation on productivity.
* By addressing these challenges and adopting a comprehensive approach that involves stakeholders from different sectors, it is possible to mitigate and prevent further land degradation and ensure the sustainable use of land resources for future generations.

**Reclamation of MINED LAND**

Mined lands can have a significant negative impact on the environment, affecting soil, water, air, plant and animal resources, and even human health and safety. To address these issues and achieve the objective of reclaiming and stabilizing abandoned mined areas, the following measures should be taken:

**Reclamation and stabilization:** The primary goal is to decrease erosion and sedimentation, support the growth of desirable vegetation, and improve offsite water quality and quantity. Properly planned reclamation can help restore the land's natural functions and minimize adverse impacts.

**Landscape visual and functional quality:** The reclamation process should aim to maintain or improve the overall appearance and functionality of the landscape. This includes preserving important features like trees, shrubs, grasses, stream corridors, natural springs, and historic structures.

**Dust control:** Mining operations can generate a lot of dust and particulate matter, which can be harmful to both the environment and public health. Proper dust control measures should be implemented during the removal and replacement of soil and materials to minimize fugitive dust emissions.

**Debris removal:** Before starting reclamation activities, it's essential to clear the area of any debris, including trees, logs, brush, and rubbish, which could interfere with the reclamation process or create environmental problems.

**Managing soil materials:** Careful consideration should be given to the disposal or burial of soil materials that could negatively affect water quality or plant growth. Soil materials containing heavy metals should be buried below the root zone or treated with suitable soil amendments to reduce their negative effects.

**Slope stabilization:** Slopes and overhanging rock walls should be stabilized to prevent erosion and ensure the safety of the reclaimed area. Proper slope angles and backfill techniques should be employed as per the planned land use.

**Adding organic matter:** Mine soils and mining wastes are often low in fertility and water holding capacity. Adding organic matter, such as bio-solids, animal manures, or paper mill sludge, can improve soil quality and enhance the success of land reclamation.

**Health and environmental concerns:** When using organic materials for reclamation, it's essential to consider health and environmental impacts. Properly managing and monitoring the application of these materials will help ensure they contribute positively to the reclamation process.

By implementing these measures and carefully planning the reclamation process, mined lands can be rehabilitated and restored to support ecological functions, benefit the environment, and protect public health and safety.

**Conclusion:**

Addressing land degradation and achieving effective land restoration are complex challenges that require collaboration among various scientific disciplines and policymakers. Standardizing terminology and methods of assessment are essential for accurate evaluation and monitoring. With the participation of stakeholders, a holistic approach that integrates environmental and agricultural research can promote sustainable land management practices, ensuring improved agricultural productivity and environmental health for future generations.