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REVIEW ARTICLE

Balancing conservation and development for achieving land degradation neutrality

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Abstract

The loss of biodiversity has risen dramatically in the face of a global emergency and worsened by human activities which involves habitat destruction, pollution, and climate change. Biodiversity is essential for sustainable development, supporting ecosystem services crucial for agriculture, forestry and climate regulation. These services are threatened by biodiversity loss, which also has an impact on world cultural heritage, economic stability and human well-being. Moreover, a decline in biodiversity exacerbates the effects of climate change, undermining ecosystem resilience and making food poverty worse. Achieving Land Degradation Neutrality (LDN), a global goal to stop and reverse land degradation through sustainable land management techniques, depends on effective biodiversity protection. LDN projects aim to balance restoration efforts against deterioration in order to preserve or improve land-based natural capital. This chapter highlights the biophysical and socioeconomic factors driving land degradation, including unsustainable agricultural practices, urbanization and climate change impacts. It underscores the importance of integrated approaches that consider ecological, social and economic dimensions in achieving LDN. Principles such as respecting human rights, promoting good governance, and engaging stakeholders are critical for successful LDN implementation. This chapter emphasizes the need for global cooperation and policy reforms to mitigate biodiversity loss, combat land degradation and ensure sustainable land use practices for future generations.

Keywords

biodiversity; conservation; land degradation neutrality; ecosystem services; sustainable land management

Introduction

Earth is facing climate emergency and biodiversity loss is going at an accelerative pace. In the ongoing and critical threats posed by changing climate, biodiversity suffers a lot (1). There are several reasons for the ongoing loss of biodiversity like change in land use, climate change, pollution, invasive alien species and direct exploitation of natural resources (2,3,4).

Biodiversity is a fundamental component of sustainable development and its impact is beyond the goals of Sustainable Development goals; SDG 14 (Life

Below Water) and SDG 15 (Life on Land) (5). It is integral to the functioning of ecosystems that provide a multitude of resources and services, which in turn support diverse societal and economic sectors. Biodiversity underpins the delivery of multiple ecosystem goods and services, which in turn support a wide range of societal objectives and economic activities (6). Ecosystems with high biodiversity provide important opportunities for agriculture, forestry, fishing, as well as for tourism and they play a key role in climate change mitigation and adaptation, in pollution control and in the provision of clean water, wood and other forest products, as well as food. Furthermore, when it comes to controlling and moderating effects on climate change, biodiversity is indispensable (7). Wetlands and forests, such as mangroves, play a crucial role in shielding various habitats from the adverse effects of climate change and global warming (8). They regulate regional climate conditions, absorb and store significant amounts of carbon dioxide and help prevent storms and flooding. It is important that we reduce the levels of greenhouse gases in our atmosphere so that these ecosystems continue providing their services.

Biodiversity loss is often the cause of land degradation, which means a decrease in ecosystem health and land productivity (Fig.1). Ecosystems with diversity are better prepared to endure changes such as water regulation, formation of soil and circulation of nutrients that are essential in stopping and reversing land deterioration. As the ecosystems and the services offered to us by nature is closely linked to biodiversity, ensuring biodiversity protection is an urgent priority in the quest for land degradation neutrality (9). These fundamental ecological activities are disrupted when biodiversity is hampered, influencing soil erosion, declining fertility and changing water cycles so as to worsen land degradation.

Biodiversity Index of different countries such as India, China, United States, Indonesia, Brazil, Mexico, DR Congo, Vietnam, Thailand, Tanzania, South Africa, Myanmar, Colombia, Peru, Malaysia, Venezuela, Australia, Ecuador, Bolivia and Papua New Guinea (Most Biodiverse Country, 2024) are represented in Fig.2. India has the highest number of vascular plant species (around 45,000) (Fig. 3). The UN Foundation also stresses how urgent action is required to safeguard biodiversity (12). They draw attention to the fact that the enormous diversity of life on Earth is facing significant challenges as a result of resource scarcity and climate change.

Why the urgency and importance of biodiversity conservation has emerged at such pace

The urgency and importance of biodiversity conservation have escalated rapidly in recent years due to a confluence of critical factors like accelerated rates of species extinction, driven predominantly by human activities such as habitat destruction, pollution, overexploitation of natural resources and climate change which have fundamentally destabilized ecosystems worldwide (13). This loss of biodiversity undermines the essential services ecosystems provide, including pollination, water purification and climate regulation, which are vital for human well-being and economic stability (14). Moreover, biodiversity loss exacerbates the global climate crisis, weakening ecosystem resilience and their ability to sequester carbon. The implications extend to food security, as diminishing biodiversity compromises agricultural productivity and resilience to pests and diseases (15). Ethically and culturally, biodiversity holds intrinsic value and is central to the livelihoods and cultural practices of many indigenous communities worldwide (16).

Ecosystem Services provided by inexhaustible resources impact biodiversity

The ecosystems interactions produce "services" that are beneficial to all of us and that we use on a daily basis (17). The stability of ecosystems and the support of a wide variety of life forms are dependent on inexhaustible resources like sunlight, wind and atmospheric cycles.

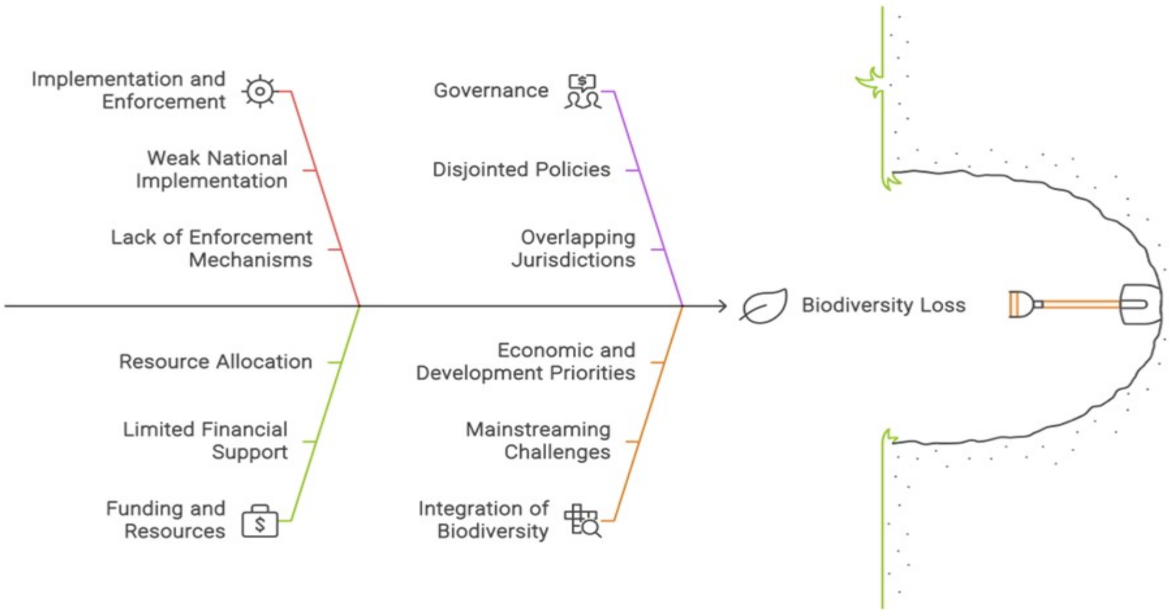

Fig. 1. Factors that lead to biodiversity loss

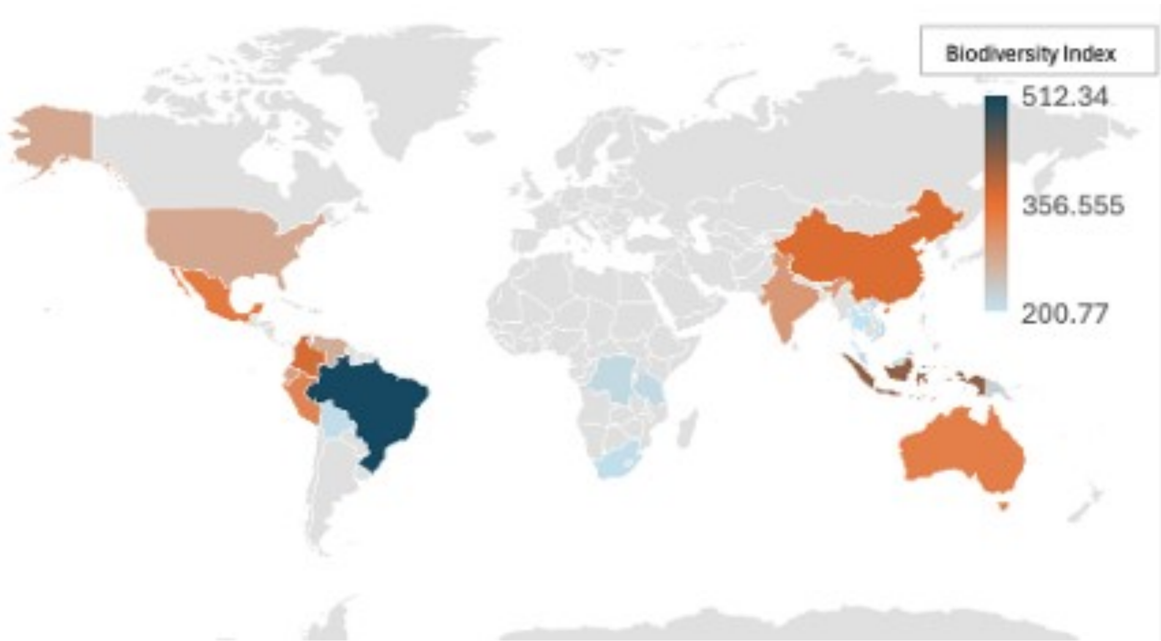

Fig. 2. Biodiversity Index of twenty countries (Brazil:512.34 , Indonesia: 418.78, Colombia: 365.84, China: 365.84, Mexico:342.47, Australia:337.18, Peru:330.12, India:301.12, Ecuador:291.58, United States:280.13, Venezuela:273.39, Papua New Guinea:226.57, Myanmar:221.77, Vietnam:216.97, Malaysia:214.71, Democratic Republic of Congo:214.43, Tanzania:213.1, Bolivia:209.55, South Africa: 207.94 and Thailand:200.77) across the globe (10).

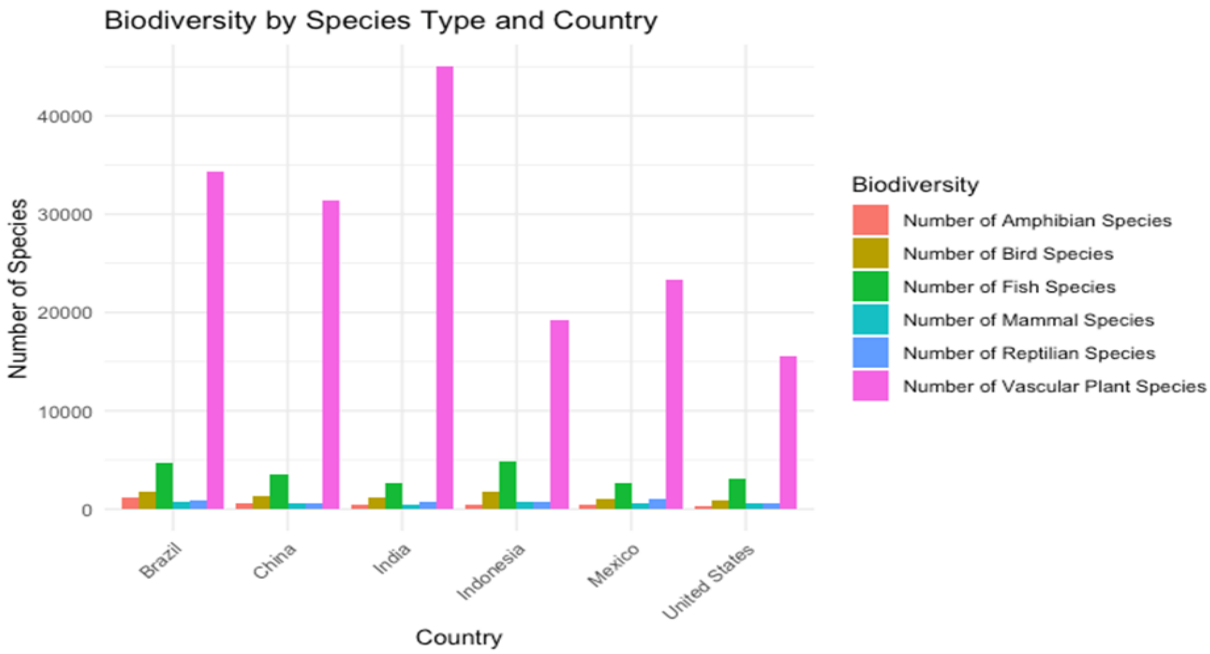

Fig. 3. Number of Amphibian, Bird, Fish, Mammal, Reptilian and Plant species in top five most biodiverse countries of the globe (11).

Photosynthesis is initiated by solar radiation, which maintains plant development and gives various species food and habitat. In the case of the water streams, the plant life plays a part in feeding other living things, influencing the biochemical cycles and maintaining sediment. The importance can be inferred by an example where Food and Agricultural Organization (FAO) says that bees pollinate 71 of the 100 crop species that account for 90% of the world's food supply (18). We work with ecosystem services every day and altering a few of their elements can have consequences on the entire network of ecosystems. Ecosystem services are essential, even in the age of technology; their disappearance would seriously endanger humankind (19). There is a synergistic trade-off between community well-being and ecosystem services where services and well-being are impacted by change in biodiversity, sustainability and climate (20). Other than above ground services soil biodiversity plays a key role in foundation of many ecological services. There has been an increase in interest and research into how the loss of soil species may impact the supply of ecosystem services and currently a lot of research shows that soil biodiversity generally has a favourable impact on ecosystem functioning and consequently, ecosystem services (21). It is evident that high plant diversity is required to continuously avail ecosystem services from forests, similarly maintaining soil biodiversity is crucial to ensuring that ecosystem services are provided in the future (22). Ecosystem services are weakened by biodiversity loss, which has real effects on tourism, health care, agriculture, and general economic stability (23). Understanding the relationship between human welfare and healthy ecosystems highlights how important it is to conserve biodiversity.

Continuous threat and declining biodiversity

Recent reports by CBD, 2020; EEA, 2019; IPBES, 2019; WWF, 2020 highlighted that biodiversity have never faced such critical loss in human history (24, 25, 26). Notably, attempts to stop the loss of biodiversity have failed for more than 50 years and it is now widely agreed that substantial changes are required to stop these trends (27). Biodiversity underpins social, economic and cultural development and it is crucial to protect our rich and diverse flora and fauna by activities such as deforestation, land use change, pollution and climate change (28). According to report by IPBES habitat change is the biggest threat, followed by overexploitation, climate change, biological invasions and biological invasion (29). The ranking can be context specific and depends on different conditions. Thus, different agencies like IPBES, WWF and IUCN together assigned different rankings based on the consequences for conservation. It is reported that biodiversity loss is 1000 times than natural rate (30). Extreme weather occurrences and rising global average temperatures are the results of human actions like deforestation and the combustion of fossil fuels (31). There is an urgent need to reduce greenhouse gas emissions and enhance forest cover in order to minimize these effects. But given present emission trends, global warming is expected to climb by 3-4°C by the end of the century, underscoring the need for further efforts to meet the goal set by the COP 21 accord to keep global warming well below 2°C (ideally 1.5°C) by the year 2100.

Urgent call for circular economy

With the goal of addressing resource exploitation present in linear systems and breaking the link between economic growth and the use of primary resources, the circular economy has surfaced as an alternative model to the traditional linear economy (32). The circular economy has become increasingly popular across the globe in response to the urgent need for change and the state of environmental deterioration, leading to the publication of national plans and initiatives (33). Though the concept's basic ideas are obvious, it is unclear how it would accomplish some goals and frequently ignores important challenges like the reduction in biodiversity. The circular economy has the potential to help society greatly, but the avoidance of evaluation has prevented it from developing into a complete solution to environmental problems (34). The circular economy promotes ideas like biomimicry, bioeconomy, ecosystem service valuation and renewable energy, all of which have their own conflicts with the preservation of biodiversity (35).

Risks to biodiversity are lowered in a circular economy that is driven by design and eliminates waste and pollution (36). For instance, removing unused plastics and redesigning plastic items in order to retain value after use, allows the products to circulate in the economy instead of being thrown away and causing environmental pollution. Rebuilding biodiversity can and must be actively pursued by economic activity (37). Regenerative farming techniques, like agroecology, agroforestry, and managed grazing, for instance, enhance soil health and sequester carbon, boost biodiversity in nearby ecosystems and keep agricultural lands productive rather than deteriorating over time, which lessens the need to expand them.

Land Degradation and its drivers

Globally, the soil erosion and desertification of the planet pose a threat to human livelihoods impacting 3.2 billion people (38). It is estimated that within 30 years, 95 % of earth's area would face degradation, 4 billion will live in dryland and 50-700 million people will be forced to migrate (39). Every year, 20 million hectares of productive land deteriorate and according to FAO, (2020), 33 % of earths soil is already degraded and over 90 % would be degraded by year 2050 (38, 40). Global food security is also impacted by land degradation, since the world's food output could decline by 12% over the next 25 years (41, 42, 43). Food costs will rise by up to 30% on average as a result of this (44). Land degradation and desertification (LDD) have increasingly become focal points in global policy discussions, spurred by the deterioration of land quality and its significant economic repercussions for populations heavily dependent on land-based natural resources (45). As the quality of land declines, whether through soil erosion, loss of fertility, or desertification processes, the capacity of ecosystems to provide essential services diminishes. This degradation not only threatens agricultural productivity and food security but also undermines the livelihoods of millions who rely on natural capital for their economic sustenance. Addressing LDD requires concerted efforts in sustainable land management practices, restoration initiatives and policy frameworks that promote resilience and conservation of natural resources (46).

Unsustainable agricultural practices, including intensive monoculture farming and improper soil management, degrade soil quality through erosion, nutrient depletion, and compaction, compromising long-term productivity (47). Unsustainable agriculture practices significantly exacerbate land degradation through several detrimental mechanisms. Intensive tillage, monocropping, and deforestation diminish soil quality and increase vulnerability to erosion, stripping away fertile topsoil essential for crop productivity (48). Inadequate soil management practices like overuse of chemical fertilizers and pesticides disrupt soil ecosystems, depleting nutrients and impairing natural fertility. Excessive irrigation can lead to waterlogging and soil salinization, rendering land unsuitable for agriculture over time. Furthermore, the clearing of forests and natural habitats for agricultural expansion diminishes biodiversity and disrupts ecosystems, further compromising soil stability (49). Overgrazing, exacerbated by unsustainable livestock grazing practices, causes vegetation loss and soil degradation, particularly in arid and semi-arid regions vulnerable to desertification (50, 51). As a result, there has been a higher understanding of the importance of using agricultural land sustainably, or to maximize yields without endangering the productivity and health of the soil.

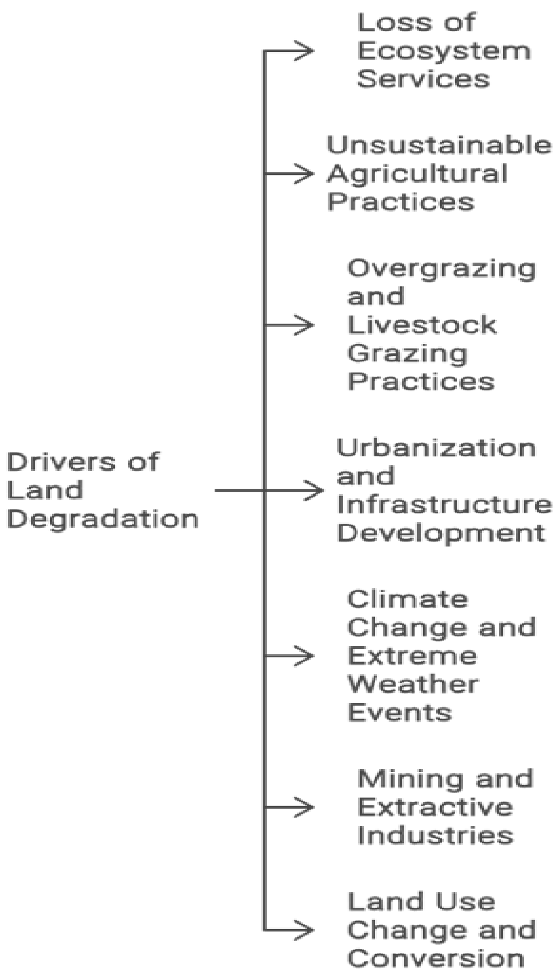

Figure 4. Different drivers of Land Degradation

Urbanization and infrastructure development alter land cover and increase soil sealing, diminishing soil fertility and disrupting natural habitats (52). Climate change intensifies land degradation through extreme weather events like droughts and floods, altering soil moisture regimes and exacerbating erosion and vegetation loss (53). Mining and extractive industries further degrade land through habitat destruction, contamination and ecosystem disruption (Fig.4). Furthermore, land use change, such as conversion of natural ecosystems for agriculture and urbanization, reduces biodiversity and compromises ecosystem services, accelerating soil erosion and degradation (54). Addressing these multifaceted drivers requires holistic approaches that integrate sustainable land management practices, policy interventions and community engagement to achieve land degradation neutrality and safeguard land resources for future generations.

Need for LDN

The concept of land degradation neutrality (LDN) has emerged as a crucial global goal to counterbalance the impacts of land degradation caused by human activities (55). The goal of LDN is to protect and improve the ecosystem services that are linked with land-based natural capital. LDN aims to achieve no net loss of healthy and productive land, ensuring that any degradation is balanced by restoration and sustainable land management practices. To maintain neutrality in land degradation, it is important to conserve biodiversity by keeping species variety and ecosystems that support land health (56). For example, different plant species improve soil structure and fertility, decrease erosion as well as increasing water infiltration rates. Biodiversity rich forests are critical for carbon sequestration, climate regulation and hydrological cycles required for land health (57). Diversity of ecosystems also reduces the risk of environmental stresses such as extreme weather occurrences or insect outbreaks hence making them more adaptable to these changes (58). The efforts for biodiversity conservation including sustainable and equitable efforts have not been successful on global scale despite many conservations' science and local knowledge growth (59).

The biophysical and socioeconomic components of the supporting systems required for supplying LDN, as well as their interactions, are the main focus of the LDN conceptual framework (60). The absence of any net loss of land-based natural capital in comparison to a baseline or reference state is implied by neutrality (61). Projecting the likely collective effects of land use and management decisions is an essential phase in planning for neutrality, as anticipated losses are weighed against actions to produce equivalent benefits (62). Sustainable Land Management (SLM) techniques that prevent or lessen deterioration are one way to attain LDN, as are initiatives to stop degradation by restoring or rehabilitating degraded land (63). The planning priority for LDN interventions are expressed in the response hierarchy: Avoid > Reduce > Reverse land degradation (51). Integrated land use planning is used to manage the landscape-level implementation of LDN and national evaluations are conducted to assess progress (64).

Achieving Land Degradation Neutrality (LDN) requires a comprehensive approach that integrates multiple principles and strategies to effectively manage and restore land-based natural capital while promoting sustainable development (60). To achieve this, we must maintain or improve the amount and quality of natural land resources, measured by land cover, productivity and carbon stocks. This involves setting national targets that align with global goals but are adapted to local conditions, based on assessments considering ecological, social and economic factors. Implementation must prioritize the protection of human rights, particularly for small-scale farmers and indigenous populations, ensuring that actions do not compromise livelihoods or cultural values (65). Moreover, LDN initiatives should adopt a participatory process, engaging stakeholders in planning, implementing and monitoring interventions, with a focus on gender equity and local knowledge integration (64). Good governance practices are essential, requiring policy reforms to address drivers of poor land management, secure land tenure rights, and ensure transparency and accountability in decision-making (66). Monitoring and adaptive management are crucial components, providing opportunities for learning and adjusting strategies based on monitoring outcomes and local feedback. By applying these principles and strategies cohesively, countries can strive towards LDN, balancing economic development with environmental sustainability and safeguarding land resources for future generations.

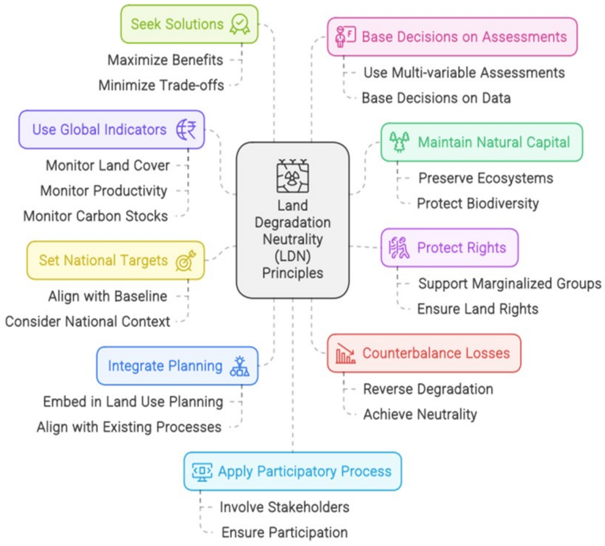

Fig. 5 Principles of Land Degradation Neutrality

Conclusion

Since there are many facets to biodiversity, such as genetic, functional, and taxonomic diversities, it is crucial that threat assessments take these aspects into account. More research on the relationship between biodiversity and the circular economy is demanded given the urgent need to protect biodiversity. Addressing LDD issues and challenges necessitates a shift towards sustainable agricultural practices that prioritize soil conservation, biodiversity preservation and efficient resource use to mitigate the impacts of unsustainable agriculture on land degradation and ensure the long-term health and productivity of agricultural lands.

A more accurate assessment of the state of biodiversity and the optimization of conservation outcomes could be achieved by offering policy makers a variety of conservation scenarios along with their anticipated biodiversity outcomes. These scenarios would take into account the various stressors, various metrics and variation across taxa. a global campaign to encourage sustainable land management and increase awareness of the financial effects of land degradation should be initiated. The goal of this project ought to be a worldwide investigation into the financial advantages of land and terrestrial ecosystems. Additionally, it need to offer a worldwide perspective for examining the economics of land degradation. It should also seek to raise public and political knowledge of the advantages and disadvantages of land and land ecosystems in order to integrate the land degradation economy into policies and decision-making processes. International policy frameworks and growing public awareness have elevated biodiversity conservation as a global imperative, emphasizing the need for urgent action to prevent irreversible ecological tipping points. Addressing these challenges requires concerted global efforts, innovative conservation strategies and a commitment to sustainable development that balances human needs with the preservation of earth's natural heritage.

Author's contributions

AK: Writing and Conceptualization. SS: Supervised the overall development of the manuscript. RK: Writing and Synthesis. MK: Contributed to the literature review and synthesis of existing research. KR: Reviewing and Refining. JJ: Reviewing and Refining. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

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