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Editorial: Land degradation pattern and ecosystem services

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Editorial on the Research Topic
Land degradation pattern and ecosystem services

Land constitutes one of the most vital natural resources and provides the basis for human livelihood and well-being through the provision of multiple ecosystem services. Globally, land degradation occurring due to unwarranted land use/land cover change (LULC) is continuing to affect the landscape multifunctionality potential, affecting the provision of ecosystem services from healthy ecosystems. Such land degradation has affected 3.2 billion people who are poor and marginalized, mainly in rural landscapes, with minimal adaptation options (Sena and Ebi, 2021). Since the Earth's land resources are finite, the sustainability of their use is the prerequisite to human well-being, as vital components for realizing sustainable development goals (SDGs) by 2030, in particular the SDG 15.3, focused on creating a world with zero net land degradation (UNDP, 2019; FAO, 2021). In this context, land use/land cover change (LUCC) is an important factor that can degrade land properties with consequences on the provision of ecosystem services. Severe soil degradation due to LULC can result in the loss in the provision of ecosystem services on a landscape scale, meaning that they are affected not only by local processes but also by landscape-level processes occurring in heterogeneous spaces. The articles included in this research topic have dealt with land degradation from different perspectives with the aim of exploring ways and means to optimize sustainable land use, management and recovery suitable to develop strategies against land degradation and to enhance the provision of ecosystem services.

The Research Topic has highlighted that some areas are more susceptible to land degradation than others (Figure 1), such as:

- Areas characterized by saline soils: analyzed in detail by Basak et al. that have presented a comprehensive review of the degradation of salt-affected soil both describing the causes and drivers for salinization as well as possible mechanism-oriented rehabilitation options. On the other side, Outbakat et al. have presented the possible environmental impacts of some saline soil rehabilitation options based on the use of Phosphogypsum and Gypsum that can cause heavy metal contamination.

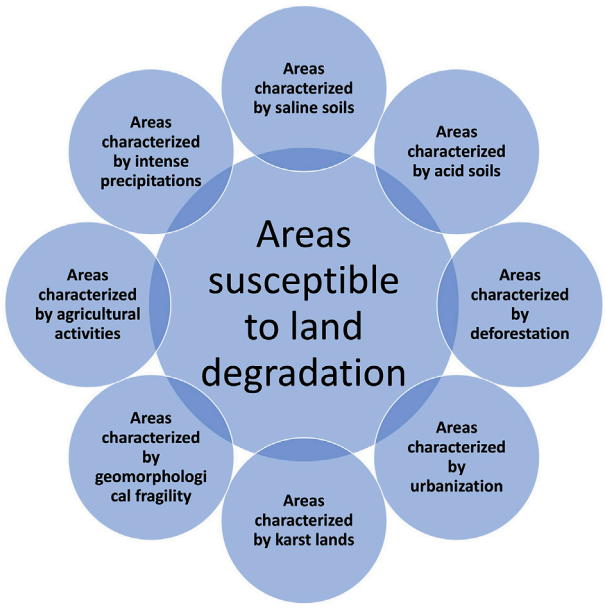

FIGURE 1
Conceptual map of the areas most susceptible to land degradation.

- Areas characterized by acid soils: where Ansari et al. have recommended a novel way to restore the soil quality and maximize crop productivity through legume green manuring and crop residue recycling in intensified cropping systems, with positive effects on supporting and regulating ecosystem services as well as on long-term productivity.
- Areas characterized by deforestation: Toro et al. have explored how socio-ecological drivers at the local scale can affect carbon dynamics across space and time in a Colombian region interested by deforestation and land use cover (LULC) changes during an armed conflict in the period 2009–2012. On the contrary, Kumar et al. have analyzed the effects of different forest management strategies in enhancing biodiversity conservation and soil carbon storage measured in terms of soil carbon density, which is one of the soil quality indicators.
- Areas characterized by urbanization: through an approach incorporating ecosystem services' supply and demand, Chen et al. have presented a novel perspective focused on ecosystem services to foster landscape optimization and conservation. The findings can have serious implications for coastal management and ecosystem sustainability.
- Areas characterized by karst lands: these are areas with great vulnerability to land degradation mainly related to land-use transformation. In this context, Liu et al. have identified priority areas for ecological restoration using transfer matrix, intensity and trajectory analysis. Their results can provide suitable insights for planning and decision making in karst regions.
- Areas characterized by geomorphological fragility: Li et al. have presented the possible mismatches between supply and demand of ecosystem services as a result of the complex interaction and comprehensive influence of multiple factors including socioeconomic development and natural factors. They found that anthropic factors were the most dominant factor influencing carbon storage, water and food provision whereas the major factor influencing soil conservation was geomorphology (i.e., mean slope) with consequences on land degradation.
- Areas characterized by agricultural activities: food supply is a crucial ecosystem services people worldwide depend on. However it depends on a good quality of soil. In this perspective, Panwar et al. have analyzed three crop management practices i) organic crop management, ii) inorganic crop management, and iii) integrated crop management, highlighting that towards organic approach (integrated application of organic amendments with a gradual reduction in mineral fertilizers) is better for keeping the rice–wheat system productive and sustainable in the long term. More in detail, Kumar et al. have focused their attention on soil C, which is severely depleted by anthropogenic activities. Also in this case, five prominent land use systems (LUS) (e.g., natural forest, natural grassland, maize-field-converted from the forest, plantation, and paddy crop) with different abilities to conserve soil organic carbon (SOC) and to emit C in the form of carbon dioxide (CO_2) have been tested. Research findings have suggested that SOC can be protected by adopting land use, namely forest soil protection, and by placing some areas under plantations.
- Areas characterized by intense precipitations: Van et al. have highlighted that soil erosion can be water-induced. In particular, they identify a two-stage process that begins with rain splash detaching soil particles from the topsoil surface and continues with surface runoff transporting the detached particles. A model based on the connections between rain intensity and kinetic energy has been developed and it was able to classify rainfall events into groups based on the magnitude of the mean rainfall intensity with different levels of soil erosion.

Degraded lands lose their ability to provide essential ecosystem services, including climate regulation, water regulation, biodiversity support, and carbon storage, potentially reducing supporting (e.g., primary production), provisioning (e.g., organic products), and regulation (e.g., carbon sequestration) services. Land degradation can be triggered by various factors, such as human activities and climatic factors with the spatial variability in soils, geomorphology, and topography impacting "vulnerability" to degradation. Improved understanding of landscape vulnerability to degradation and the evaluation of its drivers are essential to provide benchmarks and frameworks to decision-makers.

From a landscape perspective, land degradation can be seen as a loss of the ecological and economic resilience in terms of the adaptive capacity of the land system, intended as terrestrial social-ecological systems where human and environmental systems are strongly interrelated (Meyfroidt et al., 2022).

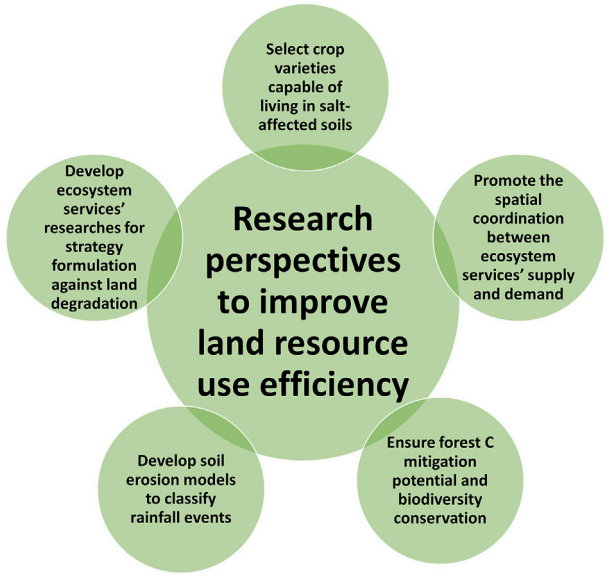

FIGURE 2
Research perspectives to improve land resource use efficiency.

The articles included in this Research Topic have presented several challenges and research perspectives to improve resource use efficiency, reduce environmental impact, increase productivity, and farm socio-economy (Figure 2):

- Improve the success of salt-affected soil by 1) selecting crop varieties capable of withstanding osmotic stress, water deficit, and toxicities of specific ions, 2) developing some formulations able to replace gypsum as an amendment for its content of heavy metals, 3) developing a soil quality index specific for salt-affected soils useful to assess the real-time impact of different management options on soil quality.
- Promote the spatial coordination between the supply and the demand of ecosystem services.
- Promote better coordination between local community and forest management agencies to ensure forest C mitigation potential and biodiversity conservation and to enhance C storage and soil functioning.
- Develop soil erosion models that employ the empirical connections between rain intensity and kinetic energy to classify rainfall events into groups based on the magnitude of the mean rainfall intensity with different levels of soil erosion at multiple geographical and temporal scales to develop more precise equations for calculating raindrop-induced soil erosion.
- Incorporate ecosystem services supply and demand perspectives for a complete and clear understanding of ecosystem evolution and ES dynamics and supports practical benefits for landscape optimization, ES management, and ecosystem conservation. However, further studies should be conducted to reveal the impacts of landscape structure on ES balance at different spatial scales and to practically support strategy formulation and implementation for combating land degradation.

Land degradation should be seen as an Research Topic interrelated with other environmental threats like climate change, biodiversity loss, food security, and the international attention is increasing year by year (Feng et al., 2022).

In setting planning strategies towards land degradation neutrality, the key principle to guide land use planning is the response hierarchy of 'Avoid > Reduce > Reverse land degradation' (Orr et al., 2017). This hierarchy highlights that the avoidance of land degradation is the most cost-effective strategy to deliver neutrality, while recovering from land degradation requires time and economic investments in replacing lost ecosystem services (Gibbons and Lindenmayer, 2007; Orr et al., 2017).

Novel instruments to assess and monitor land degradation are needed. Among others, remote-sensing data can play a leading role being a source for collecting information on the type, extent, and severity of land degradation (Prokop, 2020; de Oliveira et al., 2022).

Author contributions

Conceptualization IP, DV, and TS; Methodology IP, DV, CS, and TS; Formal Analysis IP, DV, and TS; Writing-Original draft preparation IP, DV, and TS; Writing-Review and Editing IP and DV; Visualization IP, DV, CS, and TS; Supervision IP, DV, CS, and TS. All authors have read and agreed with the published version of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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